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POWER

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OFFICE AND PLANT:
TWENTY-FIRST AND PEARL STREETS

U. G. KERR, Manager

Boulder, Colorado, Oct. 26, 1910.

The William B. Pierce Company,

Buffalo, N. Y.

Gentlemen:

We want to acknowledge our obligation to you for your courteous insistence that we keep the Dean Boiler Tube Cleaner and give it another trial, after we had written you last June that we had come to the conclusion that we didn't need it.

We have given the tool another trial, following instructions closely, and we wish to assure you that it meets every claim you make for it, and we are more than pleased with its work. We recognize in the Dean a boiler-saver as well as a fuel-saver, and would not part with it.

I am now convinced that the trial we made last June was not a fair test, for we have since discovered that the soot was not thoroughly removed from the tubes, and I am sure that the engineer in charge at that test was not inclined to give the Dean the requisite amount of steam pressure. This is the main reason, no doubt, why the Dean failed to disclose the presence of scale in any particular quantity.

In our recent trial, we removed more than 400 pounds of scale, some of which (evidently from portions of the tubes well hidden) was more than a quarter of an inch in thickness. We were not prepared for what the Dean revealed in the way of scale, for we have cleaned our boilers regularly twice a month, when in commission, and did not believe there was any scale on the tubes worth mentioning.

That we did not turn the Dean down after the trial last June is due to your faith in the tool, which faith is now ours, too.

Again thanking you for your uniform and continued courtesy, we beg to remain,

Very truly yours,

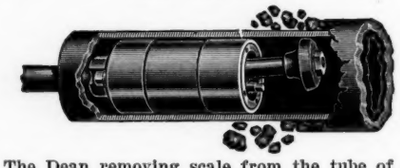
U G Kerr Mgr.

The Hygienic Ice & Coal Company.

So you could understand why we are so enthusiastic about the

Dean Boiler Tube Cleaner

The Dean removing scale from the tube of a water tube boiler.



The Dean removing scale from the tube of a return tubular boiler.

We reproduce a letter herewith which speaks for itself.

Not everybody writes a letter like that to be sure; but about everybody who tries the Dean buys it.

And what is better proof that it makes good as a scale remover?

The Dean backs up our claims—that's our reason for being enthusiastic about it.

Why not try the Dean yourself and find out what it will accomplish? We'll loan it to you for a trial in one boiler.

Write for our booklet "Scale Removal Made Easy" anyway.

The Wm. B. Pierce Company

Chicago Office:
1201 Monadnock Bldg.

Jewett Bldg., Buffalo, N. Y.

POWER

NEW YORK, MARCH 21, 1911

HERE is an experiment that all may try: Select a straight joint in the sidewalk or floor and try to walk in a straight line, using the joint as a guide.

Observe the speed you make and the degree of success you have in following the line. Then, return to the starting point, pick out some distant object and with the eyes fixed on that object start the journey over again.

Your speed in the second case will be limited only by your ability as a "Marathoner" and, provided you are sober and in normal health, your course will be a true straight line between the starting and finishing points.

Consider the tight-rope artist; he does not concern himself particularly with the rope immediately under his feet—his eyes are focused on the end of the rope. And statistics tend to show that he is right, for casualties among professional tight-rope performers are less numerous than among even canal-boat cabin boys.

The lesson to be learned from the foregoing (there's always a lesson, you know) is that the safest and best progress is made when there is a definite objective point in view. The haphazard following of a line through life with the sight limited to but a few paces in advance never got anyone very far along—there are too many blank walls against which to run and too many blind trails upon which to get lost.

If your line is steam engineering, you are to be congratulated; you are "in right." There is plenty of room and glory ahead, perhaps more than in any other line today, for this is the mechanical age. Steam engineering and other branches of mechanical science are only just coming into their own. There never was such opportunity for intelligent, earnest endeavor. But don't take our bare word for this; look it up and prove to your own satisfaction that we are either right or wrong.

Pick out your goal, keep your eye on it and work to get there. If you are in earnest, not making believe, you will make good progress. Whether you ever actually arrive will depend on so many things that we cannot make an accurate prediction. But we repeat, you will make good progress.

Hustlers are needed badly. The busy man never complains of lack of opportunity; it is only the man who is too lazy to look for it who does the croaking.

There is some slight temporary gain to be secured by "pull" and "bluff," but the worthwhile progress results only from "push" and merit.

Hydroelectric Plant in Italy

By J. B. Van Brussel

A low-head plant of 11,000-horsepower capacity supplying two transmission lines, one at 3750 volts and the other at 27,000 volts. The three-phase four-wire system of transmission is used on the line of lower voltage and the three-wire system on the one of higher voltage.

The Cervara hydroelectric plant, now in operation in the north of Italy, supplies electrical energy to the city of Terni, and to the electrochemical factories of the Societá Industriale Ellettrica della Valneria at Narni.

The water, which is supplied by the falls of the Marmore, passes into an open channel nearly 1300 feet long, 40 feet wide and 6 feet 5 inches deep with a fall of one foot in every hundred, and terminating in a clearing pond of about 25,000 square feet. Two parallel flumes, each 1640 feet in length and 13 feet in diameter, lead to an open reservoir from which intake pipes lead to 12 sluices. The original intention was to install 12 units of 1000 horsepower each, but this was later changed to six 2200-horsepower units. In order to utilize the existing sluices, each three intakes leading from the reservoir were combined jointly to feed two penstocks leading to the turbines. Nine intakes were thus combined with the six penstocks feeding the 2200-horsepower units; two more connections were used for two 1000-horsepower turbines which had been transferred from an old power house to the new generating plant, and the twelfth intake was arranged to feed two exciter turbines. In Fig. 1 only five of these penstocks are shown.

An expansion sleeve and a vertical air chamber, intended to compensate for fluctuations in pressure, are fitted to each penstock. The main locking gates of the turbines are hydraulically balanced and are controlled from the generator floor. The turbines are of the double-rim reaction type, and, according as the head varies between 65 and 79 feet, each utilizes from 2300 to 2700 gallons of water per second. Fig. 2 represents a cross-section through the turbine room and Fig. 3 is a view of the same room, showing the switch gallery at one end.

The general character of the electrical equipment was determined by the fact that two different kinds of service were required; current at 3750 volts for light and power at Terni, and at 27,000 volts for transmission to the electrochemical works at Narni. This necessitated two separate sets of busbars. At present there are installed five three-phase generators, each of 1900 kilovolt-amperes capacity coupled direct to a 2200-horsepower turbine, and space is provided for a sixth unit. Two generators of 865 kilovolt-amperes each, have been transferred from an old power house and are coupled to the 1000-horsepower turbines. Each of the larger generators can be connected to either of the busbar systems. When working on the 27,000-volt system, each of the generators is connected directly and only to a transformer of the same capacity, the high-tension side of the transformer being connected to the 27,000-volt busbars. When supplying the 3750-volt system, however, the generators are connected directly to the busbars. The two smaller generators serve the 3750-volt system exclusively. The Narni electrochemical works are fed by a duplicate three-wire transmission line and the Terni transmission line is of the three-phase four-wire type.

The basement of the switch house, which forms one end of the building, is

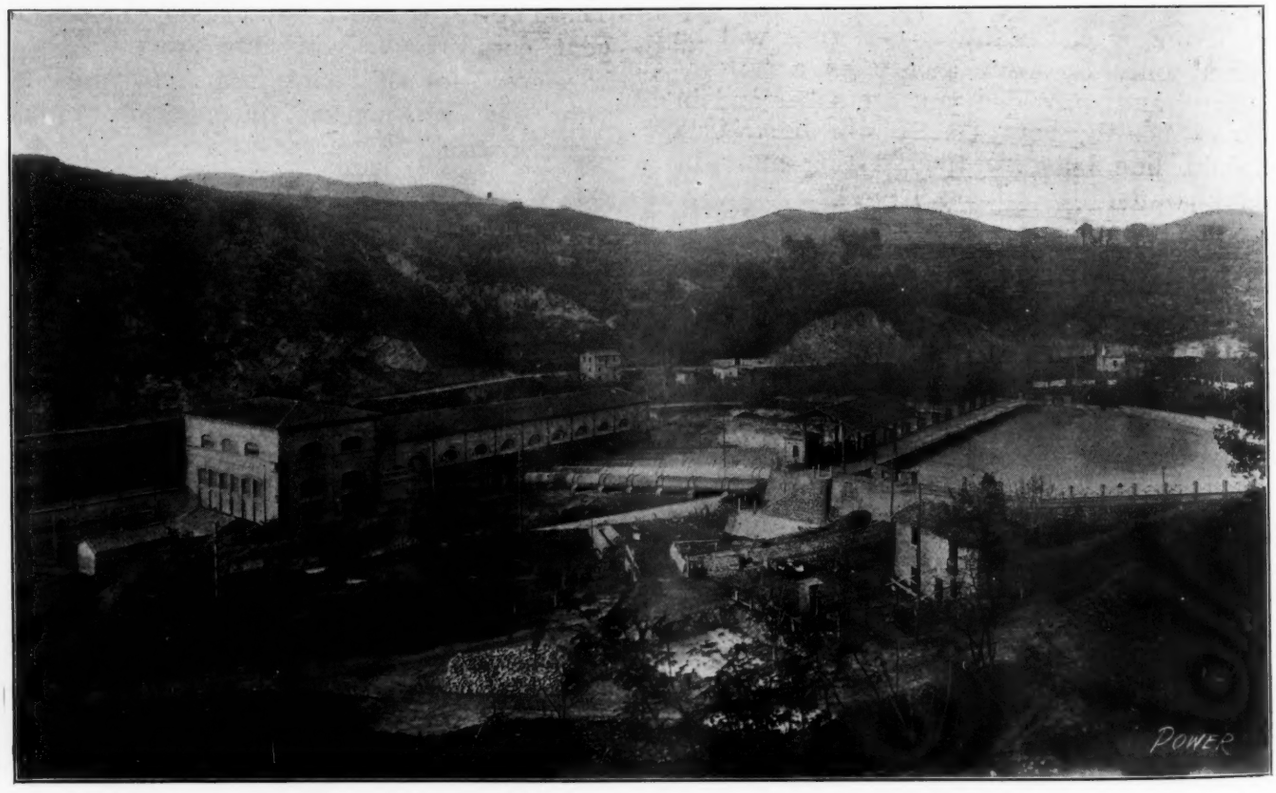


FIG. 1. GENERAL VIEW OF PLANT, SHOWING PENSTOCKS AND RESERVOIR

occupied by the generator switches and the field rheostats. The transformers are on the first floor, the transformer switches and busbars on the second floor and the line switches and lightning arresters on the third floor.

The large machines generate three-phase currents at 42 cycles and a normal voltage of 3750, although this can be increased to 4150 volts. Two direct-current turbine-driven generators of 75 kilowatts each are used for excitation. Also, a motor-generator set, consisting of a 240-horsepower three-phase motor fed from the 3750-volt busbars and coupled to a direct-current shunt-wound generator of 120 to 150 volts, is provided for additional excitation.

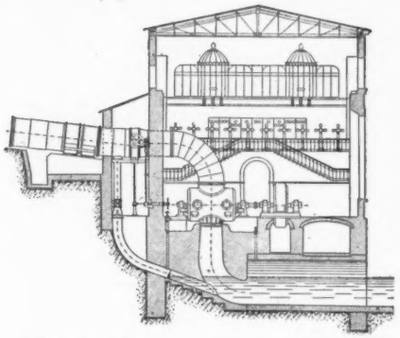


FIG. 2. SECTION THROUGH TURBINE ROOM

The generator panels are separated by fireproof partitions and each contains a four-pole oil switch with a maximum and reverse-current relay, and the knife switches for connecting the generator to either the 3750-volt busbars or to its corresponding transformer. The oil switches are operated through hand ropes from the main switchboard.

In the compartment below the switch structure are located the series rheostats for the fields of the three-phase generators and the shunt regulators for the exciters. Provision has been made for six three-phase 3750- to 27,000-volt transformers, each of 1900 kilovolt-amperes capacity, although only five are installed at present. They are mounted on wheels, which permits them to be readily removed from their stalls. An air duct running under each of the stalls is supplied by two fans, either of which is capable of furnishing enough air to keep the transformer windings cool.

From the transformers the conductors lead to transformer switches provided with maximum-current relays, which are located on the second floor. These switches, which can be operated through hand ropes from the switchboard, are designed with the terminals at the bottom and all the operating mechanism at the top. From the switches the circuit passes through three current transformers, which actuate the maximum time relay, to a structure containing the busbars and section switches.

There are two sets of 27,000-volt busbars, one serving as a spare. Each transformer, as well as the outgoing line, can be connected to either set. The current and voltage transformers, used in connection with the ammeters and voltmeters, are inserted between the connections of the large transformers and those of the outgoing lines in the 27,000-volt and the 3750-volt busbars. Section switches permit any section of the busbars to be cut out in case of breakdown, thus cutting the disabled apparatus out of the circuit.

The outgoing 3750-volt line for the Terni plant, being of the four-wire system with neutral conductor, is controlled by a four-pole automatic oil switch having a time-element relay, and operated by a hand rope from the main switchboard platform. Horn gap arresters, each with a slate-tube water resistance and four-pole water jet, are used to handle excess voltage discharges. A 60-kilowatt transformer, reducing the voltage from 3750 to 500 volts, is connected to the 3750-volt busbars for station service.

The 27,000-volt line, which comprises two three-wire transmission lines, is controlled by an automatic remote-control oil switch operated from the main switchboard. Each outgoing wire is protected against atmospheric discharges and excess voltage by a horn gap arrester and a choke coil. Figs. 4 to 7 show the switching equipment, one of the transformers and the spark gaps.

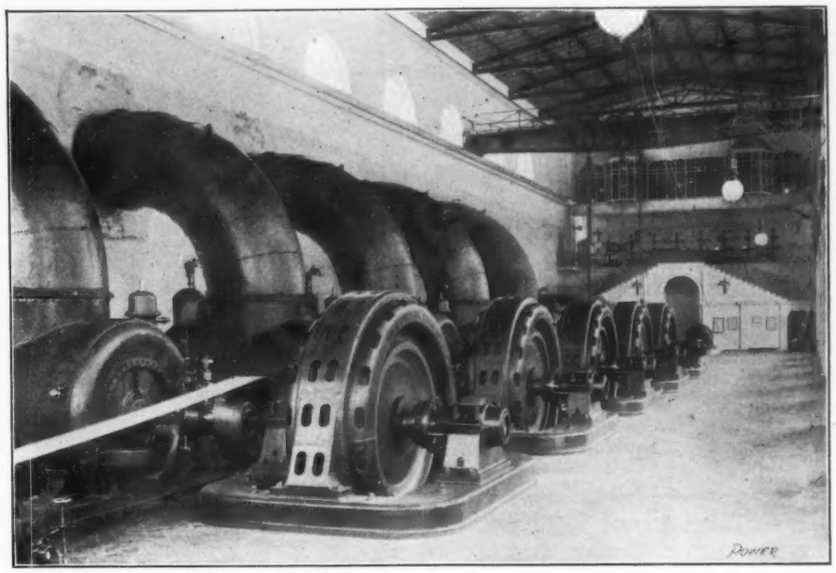


FIG. 3. TURBINE ROOM WITH SWITCHBOARD GALLERY AT ONE END

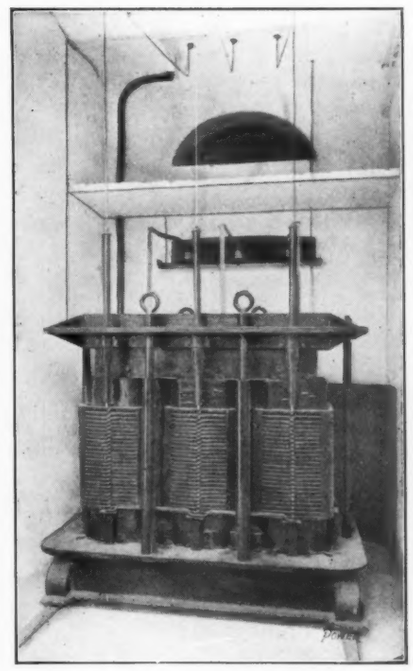


FIG. 4. TRANSFORMER MOUNTED ON WHEELS

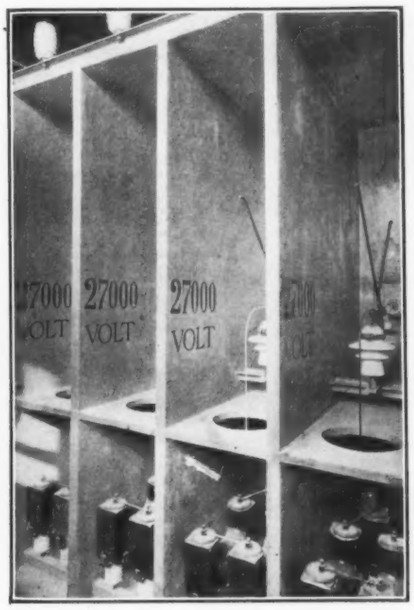


FIG. 5. HORN-GAP ARRESTER

The main switchboard is shown in Fig. 8. The instruments and operating levers for the generator sets are located on switch pedestals, while the switchboard is equipped for controlling the outgoing lines. Each of the pedestals for the 1900 kilovolt-ampere generators carries a hand lever for operating the generator oil switch, a hand lever for the transformer oil switch, and handwheels for the series rheostat in the exciter circuit and the carbon switchout of the exciter. The exciter switches are mechanically interlocked with the main switches of the generator, so that the latter can be closed only after excitation has taken place; on the other hand, the exciter switch can be opened only when the main switch is open.

The motor-generator set is also controlled from a pedestal, as are the two small turbine-driven exciters. One-half of the switchboard, shown in Fig. 8, is set apart for controlling the Narni line, and the other for controlling the Terni line.

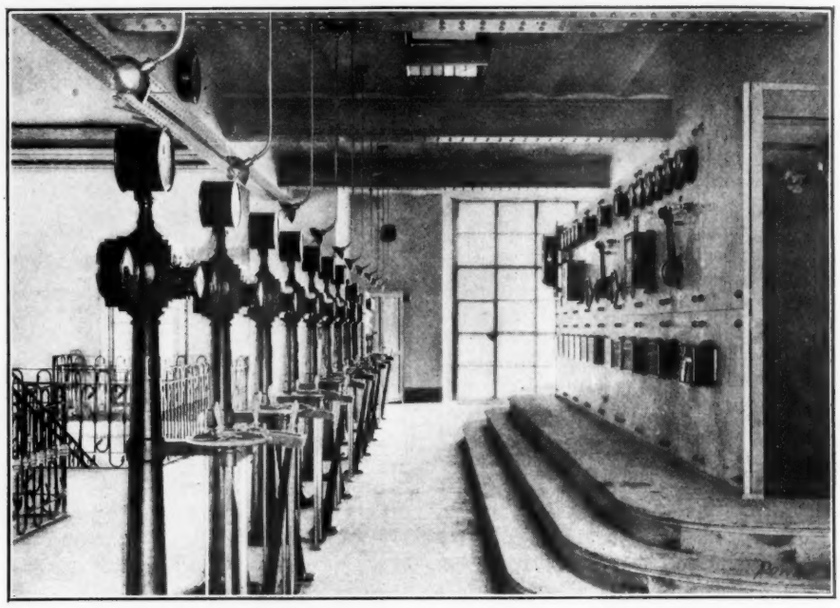


FIG. 8. MAIN SWITCHBOARD

Pierre and His CO_2 Recorder

Old Pierre, the French fireman, said that if he had that new CO_2 recorder he would fire it to the bottom of the lake where nobody would ever find it. He soon became thoroughly acquainted with the new recorder and was told that he could have it to take home when he raised the marks to 20 per cent. After receiving instructions on the theory of combustion and the principles of the CO_2 machine he was able at times to obtain about 15 per cent., which was much nearer 20 than the highest records he was able to get when the recorder was first installed. Still something strange would happen nearly every night which worried Pierre. The CO_2 would take an abrupt drop too great to be caused by any change in firing. This he could not account for. Every surmise was investigated, but the cause was not found, until finally one night Pierre rushed in—his face beamed with delight, and exclaimed, "Me finds zie troub', zie coal pass' go 'sleep in zie car, an' no coal in zie chute, zie cold air go down over zie fire an' zie machine mark a' no good."

Sure enough Pierre had located the trouble, which was soon overcome.

He decided not to throw the machine in the lake, even if he could get 20 per cent. CO_2.

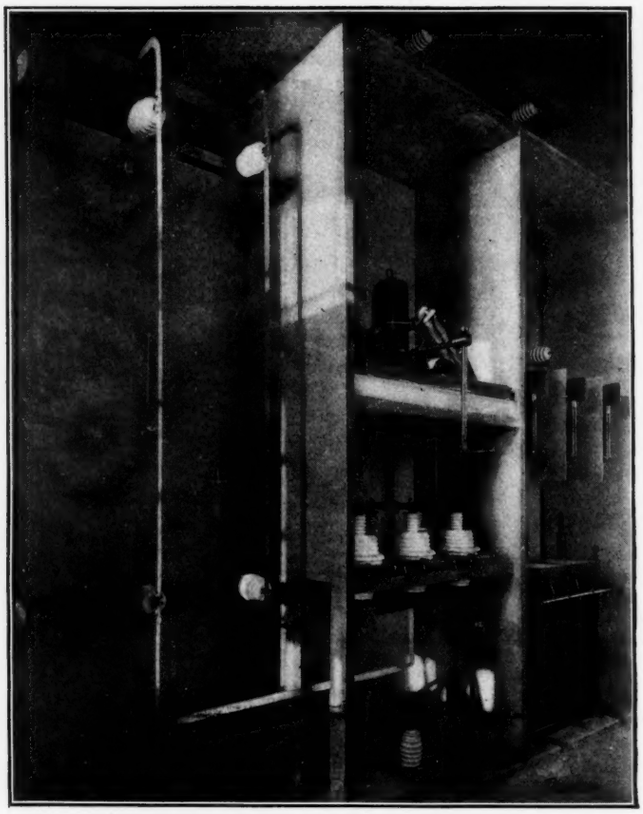


FIG. 6. MAIN-LINE SWITCHES

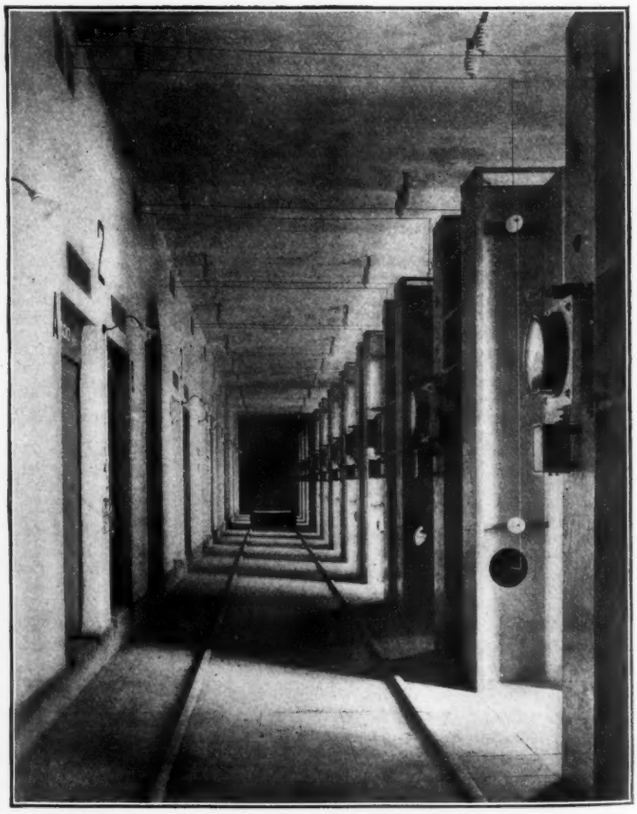


FIG. 7. PASSAGEWAY BETWEEN TRANSFORMER STALLS AND SWITCH STRUCTURE

Jet versus Surface Condensers

Some interesting data and cost figures which should aid materially in making a choice between jet or surface condensers for high- or low-pressure steam turbines.

There is a constantly increasing number of cases in connection with condensing plants for either high- or low-pressure steam turbines, where it is not obvious which is the best type of condenser to employ, and where, in fact, the wrong condenser is not infrequently selected. Little appears to have been written which is of use to power users in coming to a decision as to what type of condenser to adopt. In a recent issue of *The Engineer*, of London, an interesting article on "Jet versus Surface Condensers" was published. The following are excerpts from this article, with the exception that the English cost figures have been given their American equivalent, using $5 as the value of the pound.

In order to ascertain which plant it is best to employ in any nonobvious case, it is necessary to compare the capital outlay costs with the running costs. The former have a relatively greater importance compared with the latter if the plant has a low load factor, whereas with a high load factor the latter are of relatively

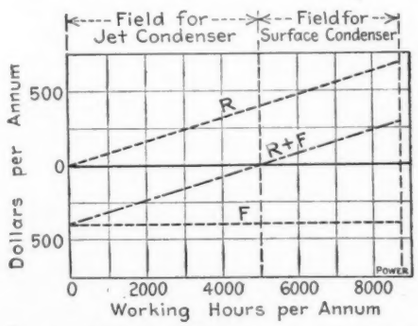


FIG. 1. TERMINAL PRESSURE AT TURBINE TWO POUNDS ABSOLUTE. CIRCULATING WATER 82 DEGREES FAHRENHEIT

great moment compared with the former. In the present investigation the condensing plant for a 3000-kilowatt turbine has been considered, and the fixed annual costs, which are proportional to the capital outlay, and are independent of the load factor, are taken at 15 per cent. of the capital outlay in the case of the surface condensing plant, including a cooling tower, and 13½ per cent. in the case of a barometric jet condensing plant, including a cooling tower. Where a cooling tower is not employed, 13 per cent. has been taken in the case of the surface plant, and 11 per cent. in the case of the jet plant.

The annual running costs, which are proportional to the load factor or to the number of hours that the plant is worked in a year, differ chiefly as regards the work absorbed in driving the air pump; and this work, with its incidental expenses, has been taken at 1.2 cents per effective horsepower-hour delivered to the air-pump piston rod or crank shaft.

Considering, in the first place, a case where a cooling tower is employed, and a turbine-terminal pressure of two pounds per square inch is desired, the cost of surface condensing plant is estimated at $19,300, which cost includes a natural-draft cooling tower capable of reducing the temperature of the condensing water to 82 degrees Fahrenheit. A barometric jet condensing plant, capable of maintaining the same terminal pressure, is estimated to cost $18,550. In arriving at the latter figure the pressure in the jet condenser has been assumed to be 0.13 pound per square inch less than at the exhaust end of the turbine to allow for drop in pressure in the long exhaust pipe and difference in level between the condenser and the turbine; 15 per cent. of $19,300 is $2895, which represents the fixed annual cost on the surface condensing plant; 13½ per cent. of $18,550 is $2500, which represents the fixed annual cost on the jet plant.

The ordinates in the figures represent annual cost, distances below the zero line being in favor of the jet condenser and distances above the line in favor of the surface condenser. The actual costs are not indicated on the diagrams, but only the differences between the costs of the rival plants. In Fig. 1 the line *F* represents the difference in the fixed annual costs between the surface and jet plants for the case just mentioned, that is, the difference between $2895 and $2500, which is $395. This is in favor of the jet plant, and is independent of the number of hours during which the plant is worked in the year.

As regards running costs the air pump of the jet condensing plant is estimated to require 14.13 horsepower, and, therefore, at 1.2 cents per horsepower-hour to cost 17 cents per hour at full load; and the corresponding figures for the surface condensing plant are reckoned to be 7.76 horsepower and 9.4 cents per hour; the difference in cost in favor of the surface plant is, therefore, 7.6 cents per hour at full load. The cost of driving the water pumps may be assumed to be the same in both cases. Line *R* in Fig. 1 represents the difference in running costs for any number of working hours per year from nothing up to 8760, which latter figure represents continuous working. The greater the number of working hours per year, the greater, of course, is the advantage which the surface plant possesses over the jet plant. The dotted line marked $R + F$ is obtained by taking the algebraic sum of the ordinates of the lines *R* and *F;* and this line represents the net difference in annual cost of the two systems for any number of working hours per year. It will be seen that the jet condenser has the advantage up to 4989 hours per annum, and thereafter the surface condenser has the advantage. Where the working hours are less than about 5000 per year at full load, it is therefore advantageous to employ a jet condenser, but, where the full power is carried for more than 5000 hours per year, it is better to employ a surface condenser.

As regards working at fractional load,

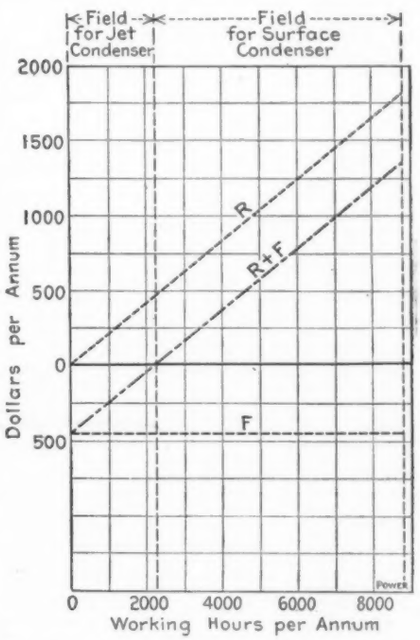


FIG. 2. TERMINAL PRESSURE AT TURBINE 1.5 POUNDS ABSOLUTE. CIRCULATING WATER 82 DEGREES FAHRENHEIT

the power consumed by the condenser auxiliaries then constitutes a greater percentage of the power of the main unit than is the case at full load. For the purposes of the present investigation, the motors driving the condensing plant are assumed to be designed to take for short periods a load considerably greater than the rated full load. A certain number of hours at a load which is a small percentage below full load may be taken as balancing an equal number of hours at which the load is about the same percentage above full load. Moreover, one hour at half load may be taken as equivalent to three-quarters of an hour at full load, so that, for example, if the plant were al-

ways running at half load, the costs for jet and surface plants, instead of being the same at 4989 hours, would be the same at 6652 hours per annum.

Fig. 1 shows that, under the conditions assumed, namely, a terminal pressure at the turbine of two pounds per square inch, and the employment of a cooling tower, there are fields of considerable extent both for the barometric jet and for the surface condenser.

For terminal pressures greater than

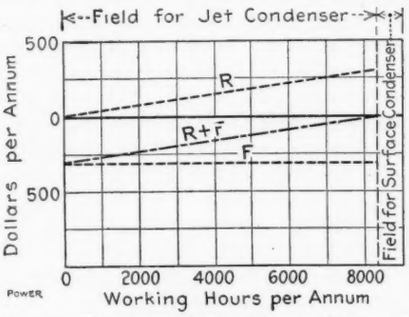


FIG. 3. TERMINAL PRESSURE AT TURBINE 1.5 POUNDS. CIRCULATING WATER 60 DEGREES FAHRENHEIT

two pounds per square inch, the field for the jet condenser is enlarged, and that for the surface condenser is reduced; but terminal pressures much above two pounds are seldom desirable for steam turbines.

For terminal pressures much lower than two pounds per square inch, the jet condenser has a very limited field. Fig. 2 corresponds to Fig. 1, but with plant designed for a terminal pressure of 1.50 pounds per square inch, a cooling tower being employed as before. The cost of the surface condensing plant is, in this case, estimated to amount to $21,600, and the jet plant is reckoned to cost $20,750. Fifteen per cent. on the former sum amounts to $3240, and 13½ per cent. on $20,750 amounts to $2800; the difference in the fixed annual costs is, therefore, in this case $440, and this is represented by the line *F* in Fig. 2. The working costs are higher in this case than in the last case, especially as regards the jet plant, which suffers not only from the greater specific volume of the air due to the lower pressure, but also from the greater weight of air admitted to the condenser due to the greater amount of condensing water required. The air pump of the jet plant is in this case estimated to require 26.8 horsepower, and, therefore, to cost 32.2 cents per hour at full load, while the surface condenser air pump is reckoned to require 10.09 horsepower, and therefore to cost 12.2 cents per hour at full load, the difference in running costs being therefore 20 cents per hour. The line *R* in Fig. 2 shows the difference in the running costs per annum for any number of working hours per annum; and the dotted line marked $R + F$ represents the difference in total annual cost. It will be seen that the jet plant has the advantage only if the plant is worked per annum an amount equivalent to less than 2112 hours at full load.

Cases will now be considered where no cooling tower is employed, and where condensing water can be obtained at a temperature of 60 degrees Fahrenheit. The lesser amount of condensing water required in such cases enlarges the field for the jet condenser, so that for a terminal pressure of 1.5 pounds per square inch the jet condenser has the advantage over the surface condenser for practically any number of working hours per year. This is shown in the diagram, Fig. 3, which is of a similar nature to the previous two diagrams. The surface plant is in this case estimated to cost $8100 and the jet plant $6900. These two sums at 13 per cent. and 11 per cent. respectively represent fixed annual charges of $1055 and $760 respectively, the difference in fixed costs in favor of the jet plant being thus $295. The air pump of the jet plant is estimated to require 15.7 horsepower, and therefore to cost 19.8 cents per hour at full load, while the corresponding figures for the surface plant

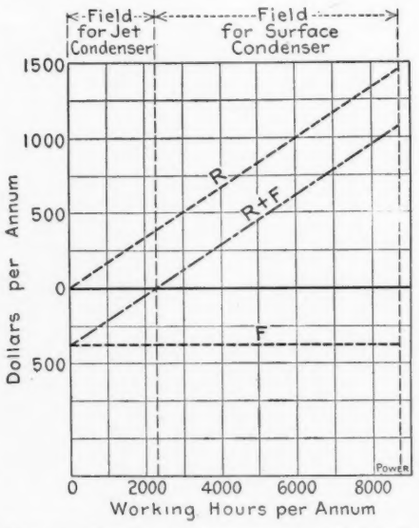


FIG. 4. TERMINAL PRESSURE AT TURBINE ONE POUND ABSOLUTE. CIRCULATING WATER 60 DEGREES FAHRENHEIT

are 10 horsepower and 12 cents. The surface plant is, however, in this case estimated to cost 3.4 cents per hour more than the jet plant for water-pumping power, so that the difference between the running costs of the two plants amounts to

$$18.8 - (12 + 3.4) = 3.4 \textit{ cents}$$

per hour at full load in favor of the surface plant.

Higher terminal pressures than 1.5 pounds with no cooling tower and with water at 60 degrees Fahrenheit need not be considered, as obviously the jet plant will have the whole field to itself. Terminal pressures lower than 1.5 pounds per square inch are, however, often desired, and Fig. 4 shows the fields for the two condensing systems when the terminal pressure is one pound per square inch. In this case the surface plant is estimated to cost $10,425, and the jet plant to cost $9000. Taking 13 per cent. of the former and 11 per cent. of the latter sum, the difference in the fixed annual cost is found to be $365. As regards running costs the air pump of the jet plant is estimated to require 28.4 horsepower, and therefore to cost 34 cents per hour at full load, while the corresponding figures for the surface plant are 11.4 horsepower and 13.6 cents. Allowing for a difference in cost of water-pumping power of 4.8 cents per hour in favor of the jet plant, the difference in running costs is 15.6 cents per hour in favor of the surface plant. The jet plant has in this case, compared with the previous case, a very limited field—only up to 2246 hours per annum—and for lower terminal pressures than one pound per square inch its field would be still further restricted.

An Inspector's Dream

BY A. C. TERLENE

It fell in my line of duty to go to a Central Western city to make the first inspection of six horizontal tubular boilers which had just been offered my company for insurance. This was a Sunday-morning inspection. The plant was a cereal factory which was in operation 24 hours per day, shutting down at midnight Saturday and starting up at midnight Sunday.

On arriving at the plant about 8 a.m., I was pleased to find that my coming had been prepared for, ashes and clinkers had all been nicely cleaned out from under the boilers, top and bottom manheads removed, boilers thoroughly washed, the furnace doors and flue caps closed and the damper opened so as to lower the temperature rapidly and remove all vapor from the interior. The tops of the boilers were all swept off nicely, smoke boxes cleared of soot and everybody was smiling and in good humor.

The chief engineer was on hand to greet me, took me into his engine room, which was nice and clean, and gave me a nice, clean locker in which to hang my clothes. The boilers were fairly hot, as might be expected, having been shut down so short a time, but by leaving the furnace doors and flue caps closed while inspecting above the flues it was quite bearable; then, when it came to going in under the flues I found that they kept a "buggy" for the purpose, this being a piece of 12-inch board 3 feet long with rollers under it. There was no scrambling along in an inch or so of dirty water in order to explore all the lower parts.

When the inspection was finished I could only report a few minor defects; the engineer, being a wide-awake man, had kept the plant in apple-pie order. I found that I had been provided with

plenty of good hot water to wash up in and on leaving the plant I did so with a feeling that if all plants were like that an inspector's life would be much pleasanter than it really is.

But did I find the above? Emphatically no! That was only my dream, superinduced, no doubt, by the fact that when this inspection was finished I would go home for the first time in six long, dirty weeks. Here is what I found. On entering the plant at 8 a.m. I saw three or four firemen and helpers sitting around smoking and was pleased to hear one call out to the others, "Here's that feller; I was hoping he wouldn't show up."

One man went to the 'phone and called up the chief engineer and reported my arrival, asking for instructions. He reported that the chief said he would be down after a while and instructed them to "tear up" as little as possible.

On reconnoitering the plant I found that most of the ashes and clinkers were still under the boilers, no manheads had been removed and only two of the boilers were entirely empty. Of course, I could see breakers ahead but went to work to get the men to prepare the boilers for inspection. The head fireman said that they never removed the upper manheads as packing cost so much and the joints were so hard to make tight; besides it took so long to do it that he could not get his Sunday afternoon off. I insisted that all manheads would have to come out and he went back to the 'phone and held another séance with the chief, who apparently agreed that the upper manheads might be removed this time but that they could not make a practice of so costly a proceeding.

I hurriedly changed clothes in one corner of the boiler room, hanging my good clothes on nails against a dirty, smutty wall, wondering all the while if they would be in such condition that I would be allowed in the hotel when I got back to that place.

I found their statement as to not removing the back manheads borne out by the fact that it was necessary to use a short piece of railroad steel to butt them in and to make a run for it when we did, so as to avoid the gust of steam which poured forth. By twelve o'clock we had the boilers in such condition that I managed to get inside and found the passages between the tubes very generally stopped with scale, the back head being covered with nearly an inch of hard scale between the tubes. The internal extensions of the feed pipe were all disconnected at the point of entrance to the boiler; some of these pipes had evidently been forced off by the pressure of the feed pump as they were completely closed up with sediment and scale. Aside from a couple of broken braces, no defects were found in the boilers above the flues.

Below the flues I found that the front ends of the boilers were several inches lower than the back ends and as a consequence three or four inches of mud and water made inspection anything but pleasant as there was no "buggy" present. Externally, I found that several of the boilers were bagged on the front sheets above the grates, the girth seams were fire-cracked and leaking, the tube ends at the rear were nearly all burned off and a number of these were leaking badly. All but two of the soft plugs had been removed and replaced with solid plugs. I found only one safety valve that looked as if it had ever blown and the attendants stated that none of the others ever opened, one safety valve doing all the "popping" for six 72-inch by 18-foot boilers. Three of the water columns were 4 inches too low and gage cocks were conspicuous by their absence from the plant. The feed-water heater, of the closed type, was out of order, and the feed water was bypassed around it, so that the boilers were supplied with cold water. The chief did not show up at all during the day and we finished the inspection by about 4 p.m. Conditions were such that I deemed it advisable to stay over till next day and see the boilers in service, and by so doing had an opportunity of meeting the chief engineer, also the officers of the company, which proved to be a new firm just taking over the plant. At the request of these men I staid over at this city three days, during which time their power plant was very thoroughly gone over, innumerable steam leaks were noted and bad conditions generally were found. On visiting this plant three months later I found a great change.

The old chief had been given a permanent layoff, the boilers had been reset, a new feed-water heater installed, the pumps overhauled and such improvements made that four boilers now carried more load than six had formerly been able to do. Worst of all, a young man, one of the much berated "technical engineers," was in the saddle as chief. He had never shoveled a pound of coal and it is doubtful if he could have made up a decent pipe joint, but he knew how it all ought to be done and he was satisfied with nothing short of "right." Things done so that they would "do for a while" did not go with him. Many of us despised inspectors have seen parallel cases. My dream only showed the difference very distinctly between what some men are doing, as engineers, and what they should do or else prepare themselves to get out in favor of the technical man.

An Example of Incomplete Combustion

It requires but a glance at the accompanying illustration to see that a large amount of combustible was being but partly consumed. The photograph was taken at a fire that destroyed a store house of the Vacuum Oil Company at Weehawken, N. J., and several thousand barrels of lubricating oil.

Oil Fire at Weehawken, N. J.

Although the fire was marked by a pillar of smoke that rose two hundred feet or more, there was but very little flame to be seen. The velvety black smoke rolled up in great profusion.

Engineers are seldom given a better illustration of incomplete combustion, or an example of a fuel being burned so fast that the necessary air to produce complete combustion could not reach it.

Burning Small Anthracite Coal

By A. S. Atkinson

The lower cost of buckwheat coal has induced many plant owners to change over from the larger sizes, regardless of whether the equipment is suitable for burning the smaller coal; hence an apparent gain is often turned into a loss. A number of practical suggestions for burning buckwheat coal are given.

The inducements for plants to burn very small sizes of anthracite coal form a temptation to change from the larger sizes to No. 2 or No. 1 buckwheat, and this, in many instances, has resulted in loss rather than gain through lack of sufficient knowledge concerning the value of the various grades of anthracite. The lower prices of the small sizes are the chief factors in influencing owners of steam plants to adopt buckwheat coal, but frequently coal dealers in their eagerness to make sales will advise wrongly as to the results.

In order not to drift into an error that will cause trouble later, it should be understood that broken, egg, stove and even chestnut coal can be handled with great ease in furnaces without any great amount of chimney draft. They will generate steam in the most economical way, and as there is relatively little ash in these coals the operation of cleaning the furnaces is reduced to a minimum. Also, if the grates have wide openings between the bars the furnaces can be operated for long periods without cleaning. These factors make the larger sizes of anthracite popular among power-plant owners, and especially among firemen and engineers; but the smaller sizes can be purchased so much cheaper that there is a constant temptation to change to them. It is quite possible in many plants to make this change and save money, but the actual difficulties and drawbacks should be realized in advance; otherwise a money-saving proposition may be changed into a loss.

The first move should be to ascertain what changes must be made in the grates and chimney. If the latter is comparatively short, barely sufficient to furnish the draft required for burning the larger coal, it will not answer for the buckwheat sizes. This fact is so often disregarded in making a change of fuel that it should be particularly emphasized. However, with steam plants as ordinarily built, it is a simple matter to increase the draft without any material alteration.

If the chimney capacity is sufficient there still remains the problem of grates. The ordinary wide spaces between the grate bars, such as are suitable for large anthracite coal, would not be satisfactory for the small buckwheat sizes. A bar of the herringbone type with air spaces one-quarter of an inch wide probably gives the best results for all-round purposes where buckwheat coal is burned. This type of grate is superior to the pin-hole grates or bars of three-eighths of an inch in diameter for the reason that the latter have a very low percentage of air space. Frequently this is not more than 10 per cent., and they are suitable for buckwheat only when forced draft is used. The herringbone type, on the other hand, averages 25 to 35 per cent. of air space, which makes it suitable for either natural or forced draft. Some plants use grate bars with an air space aggregating 45 to 50 per cent., but this is entirely unnecessary; an average of 30 per cent. answers all purposes better and works for economy, as there will then be no leakage of coal to the ashpit. Everything depends upon getting the right grate bars, the right proportion of air space, and chimneys of sufficient capacity. With these as a start the rest of the work can be accomplished with good stokers and firemen who understand how to burn small coal economically.

In using buckwheat coal for steaming purposes there is no substitute for skilled operation. It is essential to ascertain how much buckwheat coal is required to produce the same amount of steam as is generated by a certain amount of the larger coal. There is a difference in the efficiency and heat values of the two coals, and this must be ascertained and kept in mind. To ascertain how much more small coal is required, it is necessary to find the difference between the amount of ash in the two coals. When this is found by actual test it is a simple matter to calculate how much more of the small size is needed for generating a given amount of steam.

Ordinarily, buckwheat coal contains about twice as much ash as egg, but this will differ considerably in various grades. Consequently each separate lot must be tested, and the ash determined before intelligent burning can be carried on. It is true that very few companies go into all of these details, but it is also true that many are burning the small sizes at a considerable loss in economy.

A number of tests have been made with small and large sizes of coals to ascertain the relative amounts of the two fuels required to produce a given amount of steam. Without going into the details of these experiments it may be stated roughly that for the ordinary furnace it will require nearly 10 per cent. more of buckwheat than egg coal to give the same steaming results. These calculations are based upon dry coal, and when the coal is bought in a wet condition allowances should be made for the moisture. This difference is quite important. In large-sized coal the moisture is not as great a factor, but in buckwheat it is very important, often representing a difference of as much as 10 per cent.; that is, 10 per cent. of the weight of the coal when saturated may be water, and the plant owner is paying for this moisture for every ton he buys. Dry pea or buckwheat coal alone should be purchased, and if delivered wet an allowance of 8 to 10 per cent. should be deducted from the gross tonnage. Dealers prefer to deliver coal in a moist condition, but keen buyers refuse to take it by the ton weight in this condition. Likewise, when stored the coal should be kept as free from moisture as possible.

When the necessary amount of buckwheat coal has been determined, the problem of obtaining the highest efficiency from it should next come up for solution. Here the fireman will determine the economy or loss resulting from the use of the new fuel. More skill is required for firing with buckwheat than many imagine. In the first place, it must be spread lightly and uniformly over the fire, and fired at frequent intervals. Any attempt to fill the furnace with sufficient coal to last as long as the egg size means a loss; yet this is the temptation to which many yield as it is the easiest way to fire the boiler. The grate will also need more frequent and thorough cleaning with the small sizes. This means more time and labor on the part of the fireman, and unless a good man is employed, it will be neglected. A competent and conscientious workman will, however, obtain as good efficiency from buckwheat coal as from egg if the conditions of the grate and chimney are satisfactory to start with.

The small particles of buckwheat coal form a much denser and more compact bed of fuel than egg coal, and in order to make this burn satisfactorily the draft must be stronger. There must be a greater suction or pressure to get the necessary air through the bed to insure perfect combustion, and here the problem of natural or forced draft is involved. If the chimney is of ample capacity, and the grate bars are wide enough to admit plenty of air, natural draft will suffice, but if there is not sufficient draft it will then be necessary to resort to artificial draft to secure the economical results aimed at. A little previous study and

measurement of the chimney capacity and the draft at the boiler damper will obviate any trouble that may arise later.

A table based upon the results of a long series of experiments gives the following draft in inches of water at the boiler damper required for the combustion of pea coal under the best conditions:

10 pounds per square foot of grate per hour	0.30 inch
15 pounds per square foot of grate per hour	0.45 inch
20 pounds per square foot of grate per hour	0.70 inch
25 pounds per square foot of grate per hour	1.00 inch

The engineer can increase the draft or increase the grate surface, or both, to obtain the desired results, but there must be careful study of the conditions before conclusions are drawn. Buckwheat coal can be used with very wide furnaces, and also with those that are quite deep. It is particularly suited for grates up to twelve feet in depth, which makes it a very economical fuel for certain work. The coal can be spread evenly over this large grate surface, and if spread uniformly it does not have to be worked and manipulated in order to get the fire even throughout. In this respect the buckwheat has an advantage over some of the larger sizes which must be raked and poked about at intervals to secure uniform heat. In ordinary shaking grates the small sizes cause more or less trouble and extra labor. In small grates, shaking and poking may prove satisfactory in cleaning the fires, but this will hardly answer in grates exceeding eight feet in width, in which case dumping must be resorted to. If the grate is provided with a good shaking and dumping arrangement, a fire can be kept clean and bright for long periods, and then, when needed, the grate can be dumped without materially cooling the fires for any great length of time.

Small anthracite is burned most successfully in plants with chimneys 200 feet or more in hight without forced draft, but in chimneys less than 100 feet some system of forced draft is usually necessary. It is even considered advisable in some cases to use forced draft where the chimneys are very tall, just to overcome weather conditions. In such cases the forced draft is not used except on such days as the weather makes burning with natural draft somewhat difficult. The cost of the forced-draft equipment is insignificant considering the results and the efficiency and economy obtained. Where the coal tends to form bad clinkers the forced draft should be supplemented by jets of steam passing through the fuel bed; this increases the efficiency of the boiler and saves time and labor in the cleaning.

There is quite a wide difference in the quality of small anthracite. Some will clinker badly under any but the most favorable conditions, and some grades will burn satisfactorily under very unfavorable conditions. This accounts in a measure for the difference in results obtained by plants which burn buckwheat coal; one will show excellent results without many of the modern improvements, and another will show poor results. It is the difference in the burning quality of the coal. For this reason the greatest care should be exercised in obtaining a good grade of coal at all times. The difference in the cost sometimes more than counterbalances the difference in the burning qualities.

A Remarkable Overload Boiler Test

The power plant for the repair shops of the New York Central Railroad at West Albany, N. Y., has recently been nearly doubled in capacity. The original boiler installation, consisting of four 500-horsepower Franklin water-tube boilers equipped with Taylor gravity underfeed stokers, has been supplemented by the addition of three 600-horsepower Edge Moor water-tube boilers also equipped with Taylor stokers. Two 500-kilowatt Western Electric alternating-current generators direct connected to 750-horsepower Ball & Wood horizontal cross-compound engines were installed at the same time. The original generating units consisted of two 600-kilowatt General Electric alternating-current generators driven by 900-horsepower Ball & Wood engines.

In order to meet the demands for power in the repair shops it is often necessary to overload the boilers greatly and this overload is likely to continue for some time. Accordingly, it was thought advisable to subject the new units to a very severe test to determine their capacity for handling a long continued excess load. To this end one of the new boilers located at the extreme south end of the boiler room and known as boiler No. 7 was tested for 16 hours under an average load of 1129 horsepower or 188 per cent. of the builder's rating. Furthermore, during the first 14 hours of the test, the average horsepower developed was 1158, corresponding to 193 per cent. of the rating. The extreme severity of this test both on the boiler and the stoker may best be appreciated when it is considered that ordinary acceptance tests rarely exceed eight hours in length and the horsepower developed seldom exceeds 50 per cent. above normal rating. In general, for tests at higher rating, the time is cut down to six or even four hours' duration.

The test was conducted by the mechanical-engineering force of the railroad from 9:15 a.m. on October 11 to 1:15 a.m., October 12. All the coal used was carefully measured on platform scales and the amount of water used was determined by means of calibrated barrels. The Hempel apparatus was used for analyzing the flue gases. Forced draft is obtained for this installation by means of a fan blower.

The principal dimensions and proportions of the boiler and stoker are as follows: Water-heating surface, 6128 square feet; grate surface, exclusive of area of the dumping plates, 70 square feet; number of tubes, 308; size of tubes, 4 inches in diameter by 18 feet long; spacing of tubes, 15 high by 20 and 21 wide; width of stoker grate, 12 feet 7 inches; width of furnace above stoker, 13 feet 4½ inches; length of furnace to the bridgewall, 7 feet 3 inches.

The stoker used in connection with this boiler is of the seven-retort style; that is, there are seven coal-feeding chutes, each operated by a separate pair of plungers. The coal is fed in underneath the fuel bed and becomes thoroughly coked before reaching the surface of the fire. As the air supply is governed automatically by the speed of the stoker, there is no necessity for adjustment at different loads.

The principal reported data on this test follow:

Conditions.	For 16 Hours.	For First 14 Hours.
Steam pressure, lb. gage	177.8	177
Draft in stoker, in. water	4.8	4.9
Draft over fire, in. water	—0.1	—0.1
Draft in uptake, in. water	—0.42	—0.43
Temp. outside air, deg. F.	49.0	49.0
Temp. feed water entering boiler, deg. F	61.0	61.0
Temp. air supply, deg. F.	92.00	91.2
Flue gases in uptake, deg. F	546.1	543.7

Fuel Data.	
Kind of coal	Clearfield, Penn., run-of-mine
Heat units per lb. dry coal, calculated B.t.u	13,500
Proximate analysis:	
Fixed carbon, per cent.	67.82
Volatile matter, per cent.	18.98
Moisture, per cent	2.28
Ash, per cent	10.92
	100.00

Sulphur separately determined, 1.5 per cent.

Hourly Quantities.	For 16 Hours.	For First 14 Hours.
Dry coal burned per hour, lb	3,909	4,034
Combustible burned, lb	3,359	3,467
Dry coal per sq.ft. of grate, lb	42.5	43.8
Combustible per sq.ft. of grate, lb	36.5	37.7
Combustible per sq.ft. of heating surface, lb	0.55	0.56
Water evap. corrected for quality of steam, lb	32,104	32,930
Equiv. evap., including moisture in coal from and at 212 deg., lb	38,953	39,955
Equiv. evap., including moisture in coal, from and at 212 deg. per sq.ft. of heating surface, lb	6.36	6.52
Per cent. of priming	1.4	1.38
Factor of evaporation	1.21	1.21

Horsepower.		
Average h.p. developed	1,129	1,158
Builder's h.p. rating	600	600
Per cent. of builder's rated h.p. developed	188	193

Economy.		
Apparent evap. per lb. coal as fired, lb	8.14	8.12
Equiv. evap. from and at 212 deg. per lb. coal as fired, lb	9.71	9.65
Equiv. evap. from and at 212 deg. per lb. dry coal, lb.	9.97	9.90
Equiv. evap. from and at 212 deg. per lb. combustible, lb	11.60	11.52

Efficiencies.		
Grate efficiency of stoker, per cent	97.12	97.12
Boiler efficiency based on combustible, per cent	72	71.5
Combined efficiency of boiler and stoker based on dry coal, per cent	71.3	70.8

Methods of Governing Steam Engines

Combined Throttle and Variable-expansion Governing

By John Davidson

Serial with article under the above caption in the February 21 issue. In this instalment are discussed combined throttle and variable expansion governors and expansion governors for actuating trip gears.

Most modern high-speed engines are now controlled by means of a combination of both throttling and variable expansion. The governor is fixed to the crank shaft, and actuates a throttle valve in the usual way, but in addition to this, it also controls the cutoff by slightly rotating the piston valve in such a way as to alter the lead. The piston valve for engines governed in this way is necessarily of special design, and is provided with ports of angular shape arranged to engage with corresponding ports in the liner.

Fig. 13 is an elevation of a high-speed engine showing the governing gear, and Fig. 14 is a detailed view of the spring box employed for the purpose of allowing the throttle valve to act quickly and independently of the cutoff mechanism. Fig. 15 shows the developments of the valve and liner surfaces. Referring to Fig. 13, governor *A* is fixed to the engine crank shaft and is inclosed by a casing *C*. The rocking shaft *D* of the governor carries two operating arms *E* and *F*, the former controlling the throttle valve through rod *G*, and the latter the cutoff. The lever *E* is provided with a spring attachment *J* at its outer end for the purpose of regulating the action of the governor. The end of the lever *F* works in a box *K* (see detail, Fig. 14), inside of which there is a spring *M*, in compression between the end of the box and a cap on the end of the lever. When the lever *F* is moved from right to left by the action of the governor, the spring *M* is compressed and through lever *O* causes the vertical shaft *N* to rotate. As this shaft rotates through a small angle, it actuates the system of levers, shown in the small plan view, which is similar to a Stanhope lever. This lever is connected to a shaft passing through the end of the valve chamber, which, in turn, is fixed to a spider *S* mounted on an extension on the slide valve *T*. Thus the movement of the governor balls causes the angular adjustment of the piston valve *T*, and this effects the acceleration or retardation of the cutoff in the following manner:

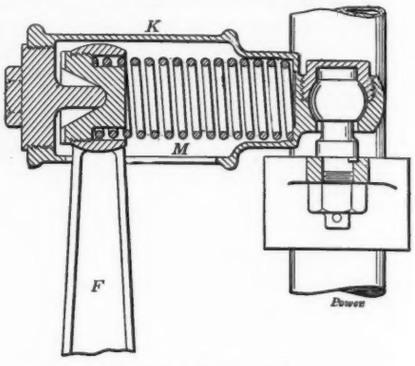


Fig. 14. Spring Box

The valve *T* is arranged to slide in the liners *U*, located at the top and bottom of the valve casing, these liners being provided with triangular ports *V*, while the valve itself has inclined cutting-off edges *W*. The triangular port is in the form of right triangle with the hypotenuse, which forms the steam edge of the port, inclined at 45 degrees. The cutting-off edges of the valve are also inclined at 45 degrees, so that an axial motion of the piston valve moves the cutting-off edges of the valve parallel with the inclined edges of the ports. The relative positions of these cutting-off

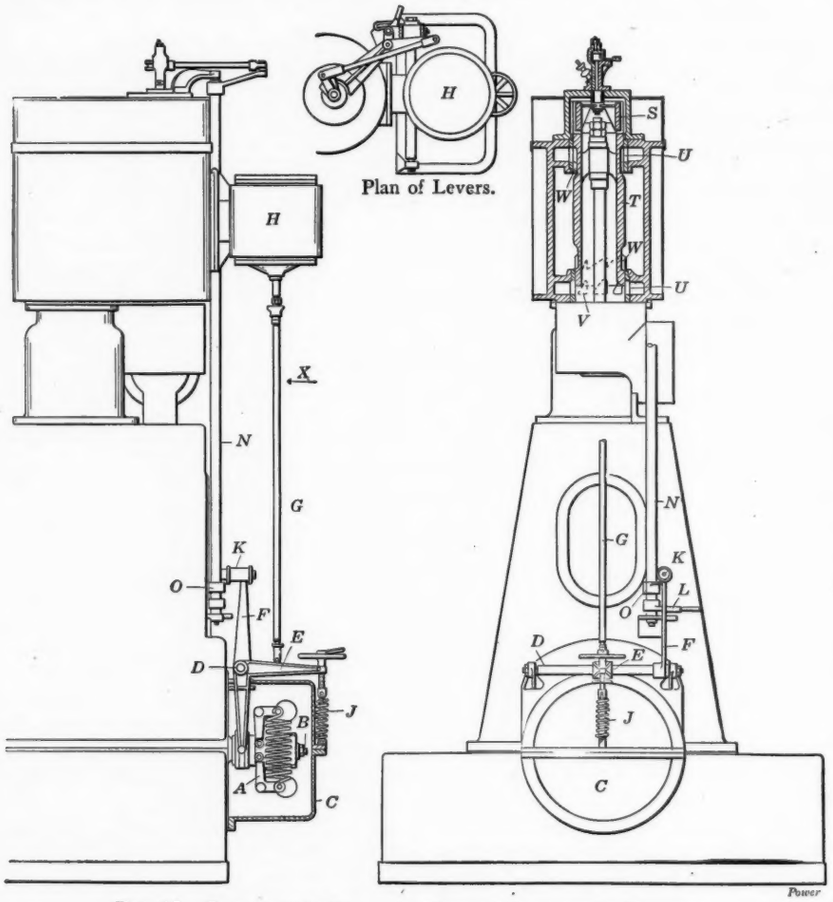


Fig. 13. Governing Gear for Small High-speed Engines

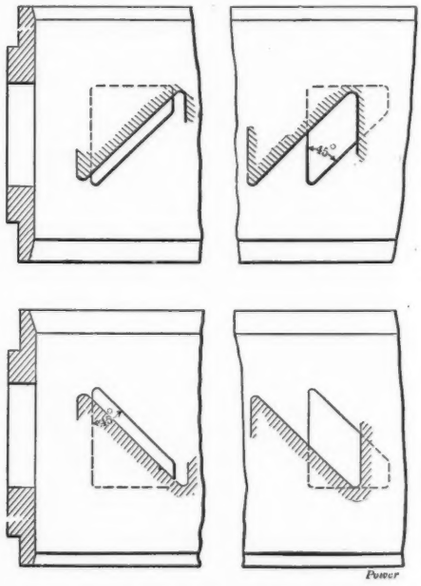


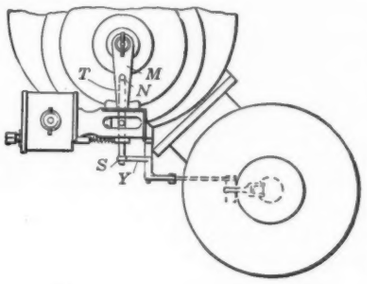
Fig. 15. Valve and Liner Surfaces

edges and ports are shown in Fig. 15, in which the left-hand view represents the relative positions when the valve is set to give the earliest cutoff, and the right-hand view the relative positions when the valve is set for the latest cutoff, these positions being taken at the same point in the travel of the valve. In order to cut off steam, the valve is required to move through a greater distance axially when in the latter position than when in the former. Also in the left-hand position the lead will be smaller than in the right-hand position, and the lap will be correspondingly greater. It has been found that with high-speed engines this reduction in the lead is no disadvantage, but has the effect of making the engine run more smoothly.

The operation of the gear is as follows: Assume first that the load has suddenly been taken off the engine. The consequent increase in speed will cause the governor balls to fly out and throttle the steam by means of the throttle valve in the casing *H*, Fig. 13. Meanwhile, the rotation of the slide valve will be much slower, owing to the intervention of the spring. The valve will, at first, be rotated through a considerable angle till that position is reached at which the speed is normal. When the point of earliest cutoff is reached, the engine is further governed wholly by throttling.

Now assume that the slide valve is at the point of earliest cutoff, the throttle valve is throttling the steam and the load is increased; the effect of this increase in load will be to open the throttle valve; meanwhile, the slide valve is not appreciably changed, owing to the action of the levers *Q* and *P*, but the throttle valve will continue to open until it ceases to throttle the steam. The arrangement of levers is so designed as to produce a material change in the position of the slide valve only after the throttle valve has ceased to throttle the steam. In this way the engine is governed at low loads by throttling, and at high loads by varying the expansion. By means of this gear it is possible to arrange for a variation in cutoff from 40 to 80 per cent. of the stroke.

With large engines, it is usual to operate the cutoff valve through a relay cylinder, thus greatly relieving the governor, as it has then only to actuate a small piston valve in connection with the relay piston cylinder. Instead of using a spring and Stanhope lever, the gear illustrated in Fig. 16 is used. Here the spring is replaced by a small relay cylinder *X* and the Stanhope lever by a cam *Y*. The upward movement of the link *G* causes, through lever *W*, a downward motion of link *Z* which is connected to an extension on the cam *Y*. While this is taking place, the throttle valve in *H* is moved as in the case previously described. The motion of the pivoted cam at first produces no effect upon the cutoff because the cam is in the form of an arc with its center at the pivot. When, however, the throttle valve has been opened to such an extent that further movement has no effect upon the control of the engine, a raised portion *R* on the cam comes opposite a follower *S*, held in place by a spring. The follower is attached by means of a lever *T* to the spindle *L* of a slide valve, which controls the admission of steam to the relay cylinder. Steam enters the valve casing *Q*, by pipe *P*, and exhausts by pipe *O*.



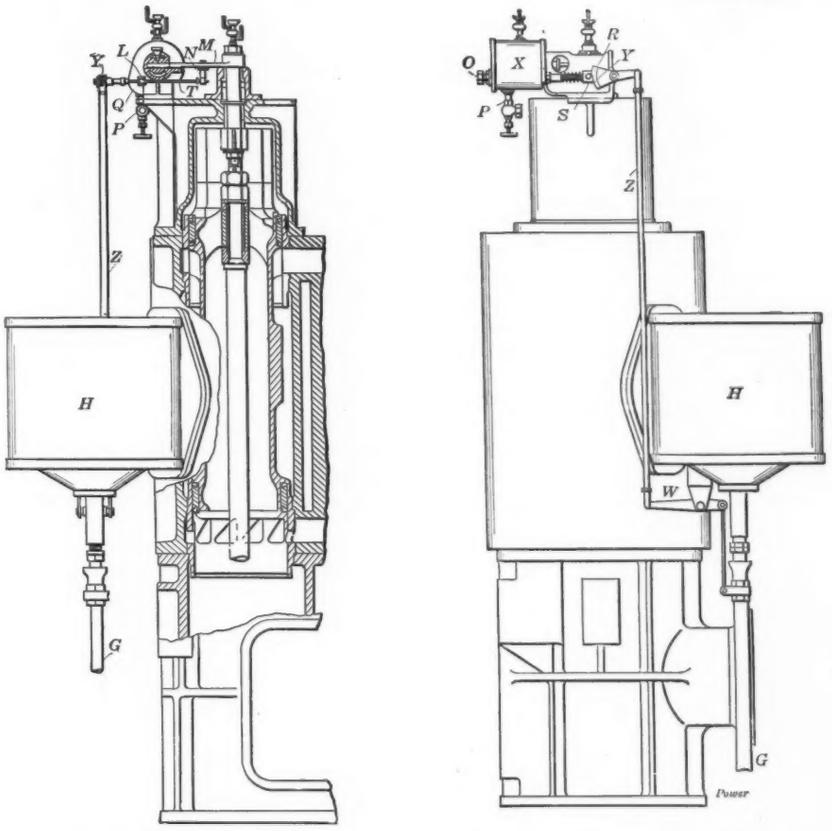


FIG. 16. ARRANGEMENT FOR REGULATING CUTOFF THROUGH RELAY PISTON

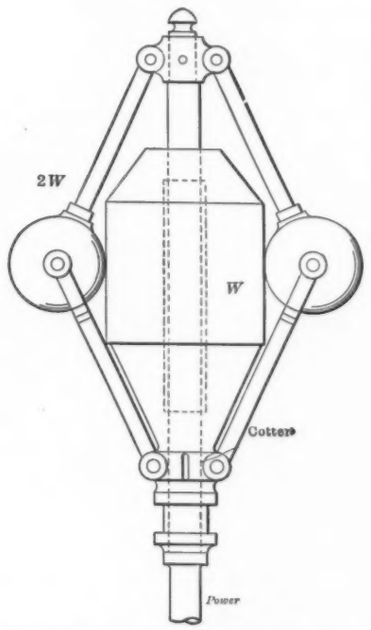


FIG. 17. ORIGINAL PORTER GOVERNOR

The lever *M* is connected to the main slide valve of the engine, or, if the engine is of the multiple-expansion type, to the high-pressure slide valve, so that the valve is turned and controls the cutoff as described in the preceding case.

Lever *T*, which carries the cam follower, is pivoted at the end of spindle *L* and also at *N* to the lever *M*. As the lever *M* is moved in a counterclockwise direction under the action of the relay piston, and the follower *S* is moved clockwise under the action of the cam, the motion of the slide valve in the casing *Q* is made slower, and more accurate adjustment of the engine slide valve is rendered possible. By this means, at light loads the engine is governed by

throttling and at heavy loads it is governed by the cutoff.

Variable-expansion Governors for Actuating Trip Gears

The governor most commonly used for this purpose is the original Porter governor, illustrated in Fig. 17, but many firms have adopted a modified form of

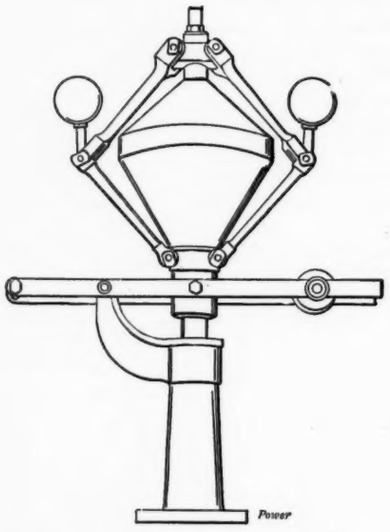


Fig. 18. Modified Proell Governor

Proell governor as illustrated in Fig. 18. The latter is very sensitive but does not possess much controlling power.

The Proell governor itself, which is illustrated in Fig. 19 is much more powerful, and at the same time is very sensitive. The governor flange *D*, which is secured to the top of the stand, has a cylindrical sleeve, into which is fitted the hollow spindle *A*. This spindle has lugs at *E* and *F*, from which are suspended two hanging straps H_1 and H_2, carrying at *E'* and *F'* two pendulums P_1 and P_2 which, at their lower ends *B* and *C*, are pivoted to the movable sleeve *S*. By this peculiar suspension of the governor balls, they are guided in a straight line, and, when revolved, describe a plane, not an arc or spherical surface, as is the case with all other governors. The straps H_1 and H_2 are continued at their upper ends as bell cranks, and these carry the cross bridge *R*, at K_1 and K_2, on hardened knife edges. Into the center of the cross bridge and into the bottom of the spindle *A* are fitted two spring holders T_1 and T_2 which hold between them a strong spiral spring in tension; this counteracts the centrifugal force of the governor balls. Many governors have been constructed on the principle of balancing centrifugal force against spring power, but as the balls open in an arc, an equal angular opening does not vary the centrifugal force in the same ratio as the compression of the spring. In the Proell governor the increase or decrease of centrifugal force is proportionate to the increase or decrease of spring power, to whatever angle the governor may be opened. This construction, therefore, secures the most sensitive regulation obtainable, while the strength of the spring and the heavy weight of the balls exert great power. With the exception of the support *D*, the whole governor is revolved by the bevel gear *W*.

A governor, which is very quick in responding to changes of load and pressure, and at the same time maintains the speed of the engine constant, is the Whitehead governor llustrated in Figs. 20, 21, 22 and 23. The balls and bell cranks are mounted on and driven by a yoke or cross bar by means of the spindle, which, in turn, is actuated by gearing or belting. The top of the spindle is a cylinder, in which a piston works, the hollow piston rod passing through the cylinder cover. The cylinder is filled with oil, which is allowed to flow from one side of the piston to the other through passages provided for that purpose. The rate of flow is controlled by the spindle acting as a valve and by the set screw at the top of the piston rod, there being a small spring at the lower end of the spindle which tends to lift the valve off its seat when the set screw is released. This combination acts as a dashpot.

The essential feature of this governor is the employment of two springs, one compressed between the sliding collar

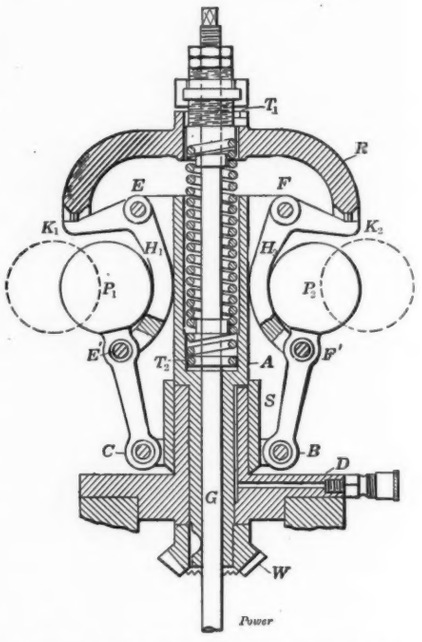
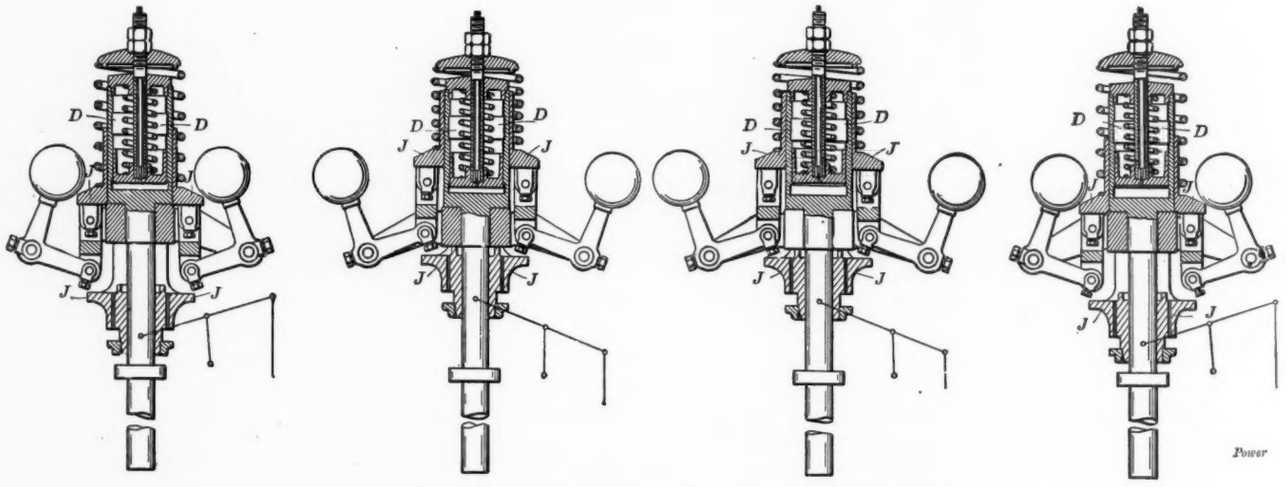


Fig. 19. Regular Proell Governor

and the plate, and the other between the piston and the cover of the cylinder. As both springs exert a pressure in opposite directions upon the plate, which is free



Figs. 20-23. Whitehead Governor in Various Positions

to move under their influence, it is obvious that the two springs must have the same degree of compression, provided the oil in the cylinder permits a movement of the piston to take place; which will, of course, occur so long as any passage exists for the flow of the

oil from one side to the other of the piston.

All ordinary governors, whether high or slow speed, sensitive or sluggish, must be designed to give a certain percentage of speed variation between no load and full load; that is, the speed at which the

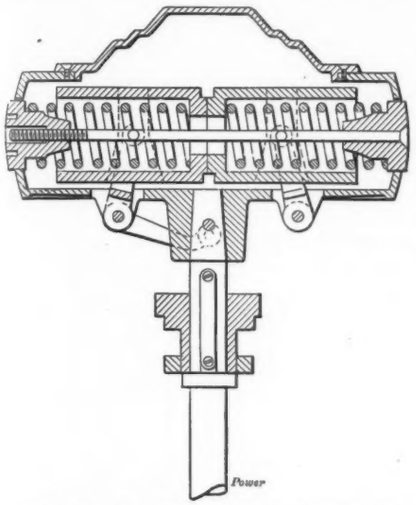


FIG. 24. HARTUNG SPRING GOVERNOR

engine will work without hunting must always be higher with light than with heavy loads, for with light loads the engine must run faster than its normal speed in order to maintain the balls in a position to restrict the steam supply. On the other hand, the engine will slow down below the normal speed when an extra-heavy load comes on, so that in reality it maintains a normal speed at one load and steam pressure only, and is only approximately correct at all other loads or pressures.

The Whitehead governor, assuming that the outer spring only is in action, would have a variation of 12 per cent., between the bottom and top positions of the sleeve, but, owing to the equilibrium sought between the two springs, this 12 per cent. of variation is eliminated, and the governor is absolutely isochronous. In order to vary the speed of a spring-loaded governor, it is usual to slacken the spring if the engine is required to run slower and to tighten it if required to run faster. Upon this fact is based the operation of the Whitehead governor.

Fig. 20 shows the governor with the balls and the sliding collar in the bottom position giving steam to the engine. Assuming the governor is set to run at 200 revolutions per minute when the engine is running at its normal speed, the springs when working together exactly balance the centrifugal force of the balls at 200 revolutions in any position; therefore, the balls do not begin to spread or move outward until they attain that speed. Presuming that the load is suddenly thrown off the engine, the speed rises and the balls spread out, due to their centrifugal force. This lifts the sliding collar until it is in its top position, as shown in Fig. 21, thereby compressing the outside spring. If it were possible then to prevent the inside spring from compressing, and the top plate from moving upward, the governor, in order to keep the balls spread out, would have to run 6 per cent. faster, or 212 revolutions per minute; but, as the compression of the main spring transmits pressure through the piston rod and piston to the inside spring, the latter will compress and the piston will move up to the position shown in Fig. 22, thereby slackening the outside, which has the effect of producing a slower speed.

It was pointed out that the two springs together exactly balance the centrifugal force of the balls in all positions; there-

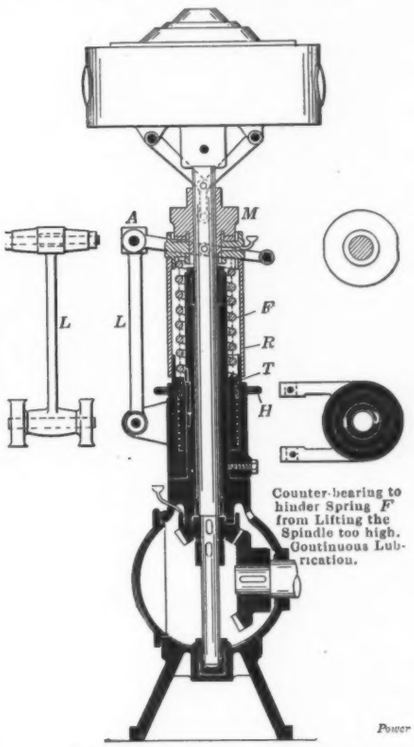


FIG. 25. TEMPLES GOVERNOR

fore, when the inside spring has finished compressing, it will have releived the outside spring so that a speed of 200 revolutions per minute will main the balls in their new position and the speed of the engine will again be normal.

Presuming now that the full load is suddenly put on again, the balls drop back and the sleeve falls to the bottom position, as in Fig. 23. In this position the inside spring is still compressed as in Fig. 22 and, therefore, the outside spring is slackened until the speed drops 6 per cent., or to 188 revolutions; then the inside spring expands, and brings down the top of the outside spring until it is again in the position shown in Fig. 20, when the speed will have risen again to 200 revolutions.

In the foregoing explanation, in order to illustrate the action as clearly as possible, it was purposely said that the inside spring begins to move after the outside spring has been compressed or expanded by reason of the balls respectively spreading or coming in, so as to prove that the governor has its outside or governing spring automatically slackened or tightened by the inside or regulating spring. This statement, however, must be modified by stating that as soon as the outside spring has its pressure increased the inside spring feels the effect of this, and at once begins to compress. It is only prevented from doing so simultaneously with the outside spring by the necessity for the oil in the chamber having to pass to the opposite side of the piston; thus the inside spring lags slightly and only completes its movement after the outside spring has come to a state of rest. In this way any extraordinary excursion of the balls is checked and all hunting is obviated.

HARTUNG'S PATENT SPRING GOVERNOR

A type of governor largely used on the Continent is the Hartung, illustrated in Fig. 24. This governor, although very sensitive, is extremely powerful. It has two hollow cylindrical weights, revolving in a plane perpendicular to the axis of rotation; and inside these weights are two compression springs. The weights are hinged on bent levers which engage at their other ends with the governor sleeve, the weights thus being kept in their positions relative to the springs when revolving. In this way the action of the centrifugal force is opposed directly by the spring, so that no pressure,

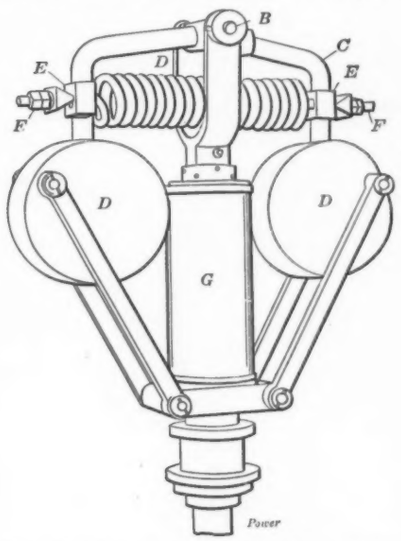


FIG. 26. TOLDES GOVERNOR ADAPTED TO ENGINES OF ONE SPEED

due to either of these forces, acts upon the levers. In this way the friction is reduced to a minimum, and the wear in the sleeves themselves is due only to the action of the force necessary to alter the trip gear, and not by any undue pressure from the springs or centrifugal force of the weights. The governor is entirely inclosed in a circular casing which gives it a neat appearance, and at the same

time, prevents dirt and dust from getting into the interior.

Another governor with weights arranged in a similar manner is "Temples

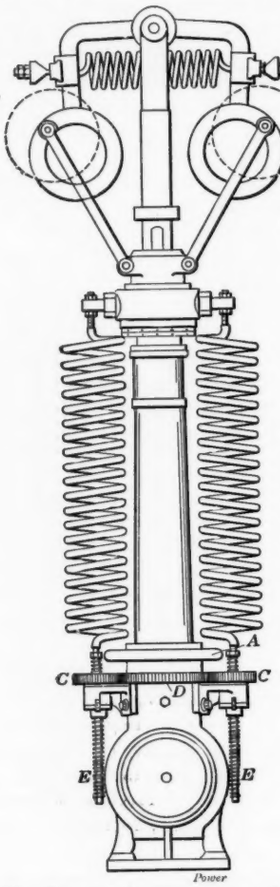


FIG. 27. TOLDES GOVERNOR FOR VARIABLE SPEEDS

patent," illustrated in Fig. 25. A change in speed is effected by means of a spring *F* coiled around the shaft of the governor; the lower end of this spring be-

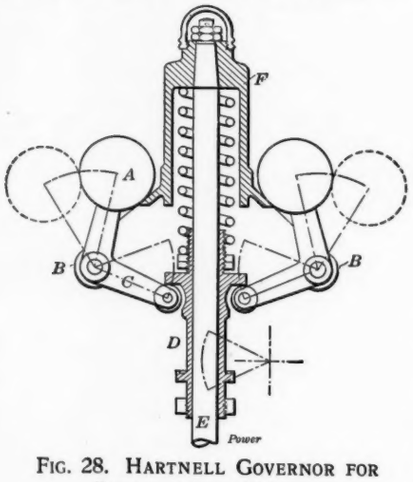


FIG. 28. HARTNELL GOVERNOR FOR SINGLE-SPEED ENGINES

ing secured by the cup *T* and the handwheel *H*, by means of which it may be more or less tightened.

The gear lever is secured by means of rod *L*, and the sliding ring can only move with the sleeve in a straight line. It is worthy of note that by this arrangement, the higher the number of revolutions, the lower the pressure of the spring, and *vice versa*. The wear of the sliding surfaces of the ring and the sleeve *M* is thus reduced to a minimum. In most other systems the loading of the sleeve has quite a different effect, for the greatest pressure corresponds to the greatest number of revolutions, which causes both heating of the sliding ring and quick wear.

Another type in which a large variation in speed is possible, is the Toldes patent governor, shown in Fig. 26, and made by Theodor Wiede's Maschinenfabrik, Saxony. The principal claim for this governor is that any change of the load on the spindle, tending to alter the speed within predetermined limits, does not affect the character of the governor in any way; that is, the degree of variation remains the same for every newly adjusted speed.

The governor consists of two weights *D D* suspended from a central pivot *B* by two bent arms *C*. The centrifugal force of the weights is balanced by the coiled steel spring *D* which acts through the knife edges *E*, the tension on the spring being adjusted by the nuts *F*. In the central casing *G* there is a smaller spring which acts on the central sleeve. If this spring is tightened the speed and energy of the governor are increased without in any way altering the degree of speed variation. If, on the other hand, the adjustment of the horizontal spring *D* is changed, the degree of variation is increased or decreased.

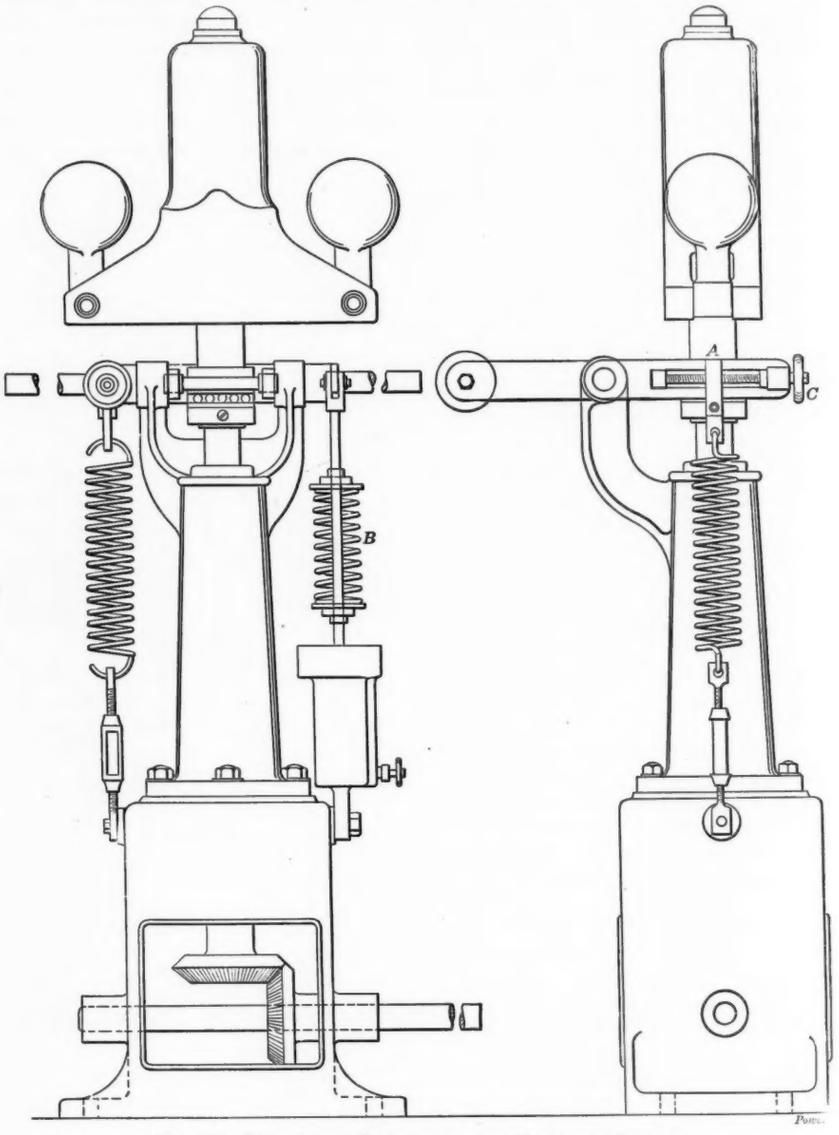


FIG. 29. HARTNELL GOVERNOR FOR VARIABLE SPEEDS

The governor illustrated in Fig. 26 is adapted for engines running at one speed only. When a considerable range in speed is desired, the central spring is replaced by two, as shown in Fig. 27, the two being adjustable simultaneously by means of the handwheel *A* actuating the gears *C C* through the central gear wheel *D*.

In Fig. 28 is illustrated a Hartnell governor. This is of the spring type and is very largely used. At *B* are pivoted the weights *A*, formed in one piece with the arms *C*, to the end of which are fixed rollers engaging a sleeve *D;* the latter slides on the vertical spindle *E*. The main governor spring is of the compression type, and is fitted between the sleeve and the cap *F*, to which are cast the lugs carrying the fulcrum pin *B*. Governors of this design are powerful and at the same time can be made very sensitive, in many instances the actual speed variation does not exceed 1 per cent.

For ordinary purposes, where an engine is only required to run at one speed, this arrangement of the governor is adequate. But where it is desired to vary the speed of the governor within moderate limits a spring is attached, as shown at *A*, Fig. 29. When the governor is used for actuating an expansion gear which will throw a reciprocating force on the governor, a dashpot is necessary; also, governors fitted to engines driving irregular loads, such as for rolling mills, etc., must not be very sensitive, and are better fitted with dashpots.

In cases where not only the speed of the governor has to be varied, but also the sensitiveness, it is necessary to vary the point of attachment of the spring. This is effected as shown at *A*, where the speeder spring is attached to a sliding block fixed to the arm, its position being adjusted by means of the small handwheel *C*.

In a few difficult cases, such as where the flywheel of an engine is small, or where there is a compound engine with a throttle valve, or with large intermediate space, or both, and where at the same time the mean speed of the engine must not vary to any extent, the governor spring is generally arranged to give a variation of, say 1½ per cent. from the mean speed. In addition there is a spring connected to the dashpot, as shown at *B*, and calculated to cause about 5 per cent. variation from the mean speed. Then, if the load be instantly taken off, the governor is at first controlled by the outer and inner spring and a considerable variation of load may take place, but as the dashpot yields the outside spring ceases to act and the engine returns to the mean speed, due to the governor only. In this case the dashpot also has a regulating screw.

All governors of the Hartnell type when used for electric-lighting purposes and where sensitive governing is required for considerable periods without stopping, are fitted throughout with ball bearings.

Modern Coal and Ash Handling System

A combination coal and ash handling equipment taking coal from tunnel cars 45 feet below the street level and delivering it to the boiler room of an office building.

In the boiler room of the Merchants' Loan and Trust Company building, of Chicago, there has recently been installed a system of coal and ash handling which, although in a cramped space, shows a good efficiency.

The coal is delivered to the building in steel cars traveling in a branch of the Illinois tunnel 45 feet below the street level; these cars discharging into a concrete pit, from which the coal is taken by a gravity-discharge bucket elevator and conveyer. This machine is equipped with V-shaped buckets secured every 2 feet with malleable-iron attachments, to two endless conveyer chains; the speed of the buckets, when in operation, being 100 feet per minute. Referring to the illustration, it will be noted that the buckets, when traveling horizontally, push the material along in a steel trough and, when traveling vertically, automatically adjust themselves and lift it as does a bucket elevator.

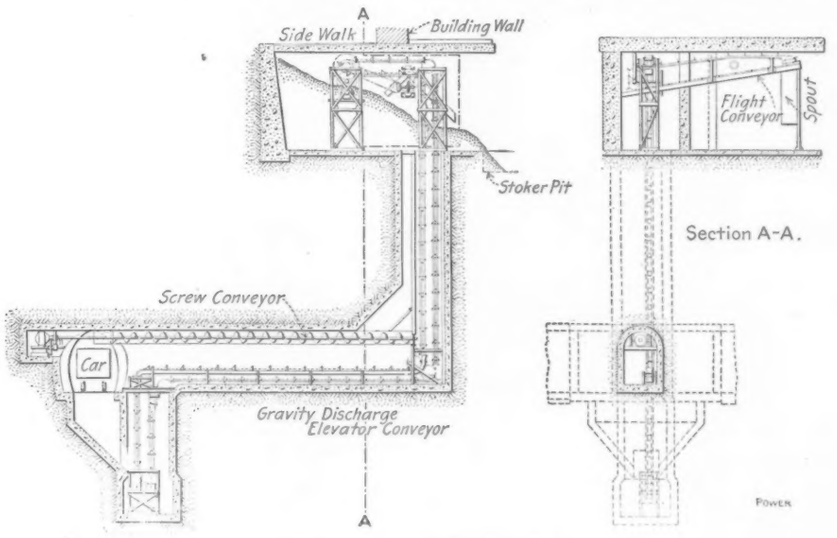
The machine first lifts the coal 12 feet to the tunnel level, and conveys it to a point 30 feet away where it is again lifted 35 feet to the boiler room and discharged into the trough of a flight conveyer running at right angles to and in front of the boilers. The latter conveyer consists of a single endless chain, running over two sprockets, placed at 20-foot centers and mounted on a steel frame. Fastened to the chain are steel flights, 2 feet apart, which, on the lower run, push the coal along in a trough. The coal is discharged through an opening in the trough and spouted to the storage pile in front of the boilers.

The present boiler equipment necessitates firing by hand, hence the storage pile. It is intended, however, to install new boilers equipped with mechanical stokers and the same conveying system will be adaptable to the new arrangement. The short flight conveyer will be removed and the gravity-discharge conveyer will be run up over the boilers and discharge into a 200-ton storage hopper, thence down and under the boilers where it will receive the ashes and convey them to the grating above the concrete chute shown in the illustration. The single machine will then be delivering the coal and hauling away the ashes in the most efficient manner possible, and this will practically do away with all manual labor in handling coal and ashes.

At the present time the ashes are shoveled onto a grating through which they pass into the concrete chute, discharging into a special 16-inch cast-iron screw conveyer; this, in turn, conveys the ashes to the tunnel, where they are delivered into cars. This conveyer is equipped with a sliding steel trough at the tunnel end, which may be run out directly over the cars.

The gravity-discharge elevator and conveyer and the flight conveyer, are both driven through two gear trains by an electric motor, which is fitted with a rawhide pinion to eliminate the noise.

The present equipment is capable of handling 40 tons of coal per hour and was designed and manufactured by the Stephens-Adamson Manufacturing Company, of Aurora, Ill.



ELEVATION OF CONVEYER

Electrical Department

Especially conducted to be of interest and service to the men in charge of the electrical equipment

Jones; Trouble Killer

SECOND TALK ON POWER FACTOR

"Now this matter of power factor is simple enough," said Jones, when he and the engineer got back from dinner, "when you once get the hang of it, but I'll admit that it isn't easy to get the hang of it."

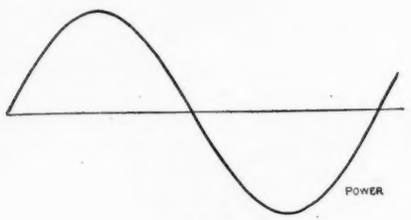


FIG. 2.

He fished out his loose-leaf book and turned over to a page of diagrams. Pointing out one that looked like Fig. 2, he said:

"You know what that is, of course."

"Sine curve," said the engineer, with conscious pride.

"A—a—it's a wave of—a—wa—"

"A wave of electromotive force, eh?" suggested Jones with good-natured sarcasm. "It naturally wouldn't be a wave of sea water, now would it?"

The engineer rubbed his nose and dug hard into his mental recesses but they refused to deliver any inspiration. He shook his head slowly.

"I know," he said, "but I don't know how to say it."

"I know you know," said Jones, "and you know how to say it, too, but you're rattled a little, that's all. Tell me this: How many times does the e.m.f. represented by that curve rise to its maximum value?"

"Twice; once positive and once negative."

"All right. Now, what is it that is made up of a rise to positive maximum, a drop to zero, a rise to negative maximum and another drop to zero? What does that constitute?"

"One cycle."

"Of course. Then this sine curve representing an e.m.f. wave is a curve showing what?"

"The changes of pressure during one cycle," hastily replied the engineer.

"Now you're on the job," said Jones, with an approving extension of his grin. "You know that if a recording voltmeter could follow the changes of pressure exactly as they occur, it would draw a diagram like that for every cycle, don't you?"

The engineer nodded. "Just like a steam-engine indicator draws a diagram of steam-pressure changes that happen in the cylinder," he suggested.

"Correct," said Jones. "Of course, no voltmeter is sensitive enough to follow the changes of e.m.f. through a cycle, because of the inertia of its parts, and it couldn't be made to follow 'em accurately anyhow, the way voltmeters are made, even if it had no inertia. But that curve corresponds exactly to the steam-pressure curve drawn by an indicator."

"But what's that got to do with the power factor?" asked the engineer.

"Keep your shirt on; I'm coming to that as fast as you'll let me," responded Jones.

"If a recording voltmeter could be made to draw the e.m.f. curve showing the changes during each cycle," he resumed, "a recording ammeter made just like it would draw the same sort of a curve to represent the rise and fall of current in the circuit, wouldn't it?"

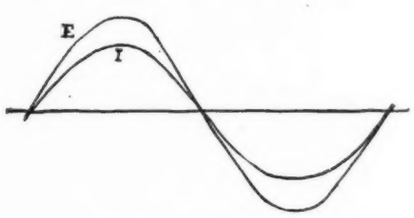


FIG. 3. JONES' SKETCH

"Of course," agreed the engineer.

"And if you could arrange 'em to draw the two curves on the same sheet of paper at the same time, the diagram would look something like this, wouldn't it?" asked Jones, drawing Fig. 3.

"I dunno, but I sh'd think so," said the engineer dubiously.

"Well, it would," Jones assured him, "*provided*—now mind what I'm saying—

"NEGATIVE POWER IS POWER DELIVERED TO THE GENERATOR FROM THE CIRCUIT."

"Right. What does it represent?"

"An e.m.f. wave," said the engineer, swelling still more.

"What's an e.m.f. wave?" demanded Jones, regarding the engineer with a lively twinkle in his eyes.

provided the e.m.f. and the current were in phase or in 'step' with each other."

The engineer nodded.

"But suppose the current lagged behind the e.m.f. in its rising and falling—didn't reach its highest point until after the electromotive force had passed its highest point and was falling. What kind of a diagram would your voltmeter and ammeter draw?"

The engineer brightened up. He had been rereading the old Electrical Catechism printed in POWER ten years ago and his memory was clearing.

"About like this," he suggested, drawing Fig. 4, "if the difference in phase wasn't very big."

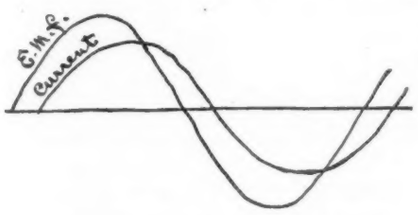


FIG. 4. THE ENGINEER'S SKETCH

"Good boy," Jones ejaculated, "you're getting close to the throne." Thumbing over the leaves of his book he pulled out another diagram, which is reproduced in Fig. 5.

"Here's a diagram of lagging current all scaled up for convenience in figuring the effects of the lag. Before going into that, though, do you understand why I've got the e.m.f. cycle scaled in three hundred and sixty divisions?"

a cycle as though it were a circle, which you know was divided into three hundred and sixty degrees for astronomical reasons."

"Dunno anything about that," protested the engineer, beginning to feel that he was over his head.

"You don't need to," said Jones reassuringly, "that's just a little off the track."

The engineer grinned. It was seldom he caught Jones in anything bordering on bad judgment and he enjoyed it.

"Well," resumed Jones, "as the cycle has been divided into three hundred and sixty degrees for scientific convenience, we may as well stick to that arrangement in talking about the physical part of the game. A half cycle, then, is what?"

"One hundred and eighty degrees," replied the engineer promptly.

"Right. Now look at my diagram and tell me how much the current is supposed to lag behind the e.m.f. in that diagram."

"Thirty degrees."

"What part of a cycle?"

The engineer scribbled on his scratch pad as follows:

$$30 \text{ degrees} = \frac{30}{360} \text{ of a cycle}$$

$$\frac{30}{360} = \frac{3}{36} \text{ and } 3)\frac{3}{36} = \frac{1}{12}$$

"A twelfth," he announced.

"Right. Now, when the e.m.f. is at its maximum, which is a hundred and fifty volts, where is the current?"

a list of the e.m.f., current and power values at each fifteen-degree division of the e.m.f. cycle," and he turned the diagram sheet over, showing on the back of the sheet the following table:

MOMENTARY VALUES OF VOLTAGE, CURRENT AND POWER, WITH CURRENT LAGGING 30 DEGREES.

Point in the Cycle.	Momentary Values.		
	Volts.	Amperes.	Watts.
Beginning	0	—175	0
At 15 degrees	+ 38.82	— 90.59	—3,517
At 30 degrees	75.00	0	0
At 45 degrees	+106.07	+ 90.59	+ 9,609
At 60 degrees	129.90	175.00	22,733
At 75 degrees	144.89	247.48	35,857
At 90 degrees	150.00	303.11	45,467
At 105 degrees	144.89	338.07	48,983
At 120 degrees	129.90	350.00	45,467
At 135 degrees	106.07	338.07	35,857
At 150 degrees	75.00	303.11	22,733
At 165 degrees	38.82	247.48	9,609
At 180 degrees	0	+175.00	0
At 195 degrees	—38.82	+ 90.59	—3,517
At 210 degrees	75.00	0	0
At 225 degrees	—106.07	— 90.59	+ 9,609
At 240 degrees	129.90	175.00	22,733
At 255 degrees	144.89	247.48	35,857
At 270 degrees	150.00	303.11	45,467
At 285 degrees	144.89	338.07	48,983
At 300 degrees	129.90	350.00	45,467
At 315 degrees	106.07	388.07	35,857
At 330 degrees	75.00	303.11	22,733
At 345 degrees	38.82	247.48	9,609
At 360 degrees	0	175.00	0

The engineer turned the sheet over and back several times, comparing the table with the diagram.

"Let's see," he began, a little uncertainly, "at fifteen degrees the e.m.f. is thirty-eight point eighty-two volts 'n' the current is ninety 'n' fifty-nine hundredths; multiplyin' one by the other gives thirty-

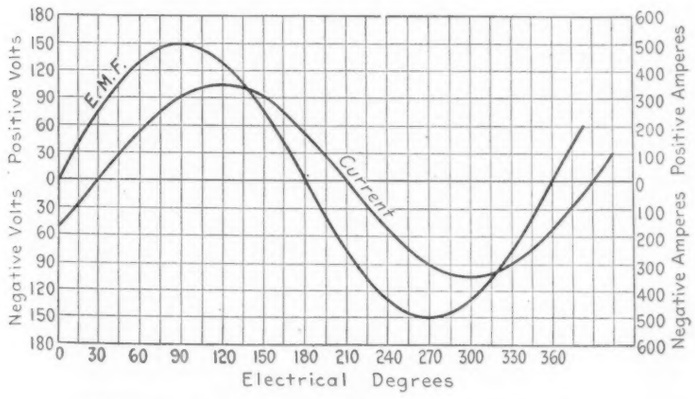


FIG. 5. E. M. F. AND CURRENT CURVES; CURRENT LAGGING 30 DEGREES

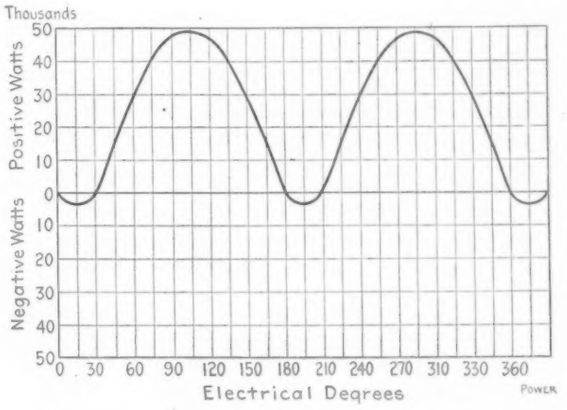


FIG. 6. POWER CURVE CORRESPONDING TO THE CURVES IN FIG. 5.

"Because a cycle's got three hundred and sixty degrees, like a circle," ventured the engineer.

"Well, that's not exactly the right answer. A cycle hasn't any degrees, and there is no physical reason why it should be divided into three hundred and sixty any more than a hundred or a thousand or any other number. It is divided into three hundred and sixty degrees for purely mathematical reasons—merely because it makes easy figuring to consider

The engineer scrutinized the diagram closely, and tried to find the scale value opposite which the current curve crossed the ninety-degree line.

"The current's three hundred and fifty amperes at the top o' the wave 'n' it looks like three hundred at the ninety-degree line," he said, "but I can't measure it fine enough."

Jones chuckled.

"Of course you can't," he said; "I just wanted to work you a little. Here's

five hundred 'n' seventeen watts—that right?"

"Bet your socks," assented Jones more enthusiastically than elegantly.

"But the watts go down to zero at thirty degrees from the beginning," said the engineer, "how's that?"

"What's the current at that point?" asked Jones.

"Zero—oh! You can't have any watts without any current, of course," sheepishly. "Well," he continued, "that's a pretty

table but it don't tell me much about power factor."

"It will if you look at this diagram at the same time," said Jones, producing Fig. 6. "That curve is what you'd get if you plotted the momentary power values given in the fourth column of the table."

"What do the little loops below the zero line mean?" asked the engineer.

"Negative power;" replied Jones, "that is, power that is delivered to the generator from the circuit."

The engineer stared at him, dumfounded.

"Look at the other diagram," said Jones. "During the first thirty degrees of the cycle the current curve is below the zero line, isn't it?"

"Yes."

"And the voltage curve is above, isn't it?"

"Yes."

"Well, what do those locations mean—what polarities?"

"Positive above and negative below," promptly.

"Right. Now, if you multiply a positive quantity by a negative quantity the product is negative, isn't it?"

"Yes, but ——"

"Never mind butting. Positive volts multiplied by negative amperes make negative watts. Negative watts mean power transferred from the line to the generator. Now look at the table and tell me what the maximum watts are during the first thirty degrees."

"Thirty-five hundred and seventeen," replied the engineer.

"That's negative power," said Jones, "that's why it's fenced off from the rest of the figures with the line across the table. You'll find another period of negative power during the first thirty degrees of the second half of the cycle; that's ruled off, too."

The engineer scanned the table and compared the diagrams with it.

"Then from the beginnin' of the cycle to the thirty-degree point the power's negative," he ventured inquiringly; "from there to the one hundred and eighty-degree point it's positive; from one hundred and eighty to two hundred and ten degrees it's negative again, and positive the rest of the cycle?"

Jones dealt him an approving thump on the back and nearly cut his own head off with his expanding grin.

"You're commencing to show signs of human intelligence again," he said. "Now tell me what's the biggest value of positive watts in the table."

"Forty-eight thousand nine hundred and eighty-three," replied the engineer, "and it happens at one hundred and five 'n' two hundred and eighty-five degrees."

"Right you are. Now what's the *average* positive watts?" he demanded, regardless of grammar.

"D'you mean the effective value?" asked the engineer.

Jones nodded.

"Forty-eight thousand nine hundred and eighty-three multiplied by point seven nought seven," began the engineer ——

"Hold on; the effective watts aren't figured that way," said Jones.

The engineer scratched his head and studied Jones' countenance for enlightenment, without success.

"Ain't the effective voltage seven-tenths of the maximum voltage?" he asked.

"It sure is," agreed Jones.

"Then ain't the effective power seven-tenths of the maximum power?"

"It sure is *not*," said Jones.

"Give it up then," said the engineer in disgust. "I thought I did know that."

"You won't give it up, either," said Jones. "Suppose, for a moment, that the current and e.m.f. were in phase. The maximum watts would be figured how?"

"Maximum volts multiplied by maximum amperes."

"All right. Now reduce 'em to effective values."

"Effective watts are effective volts times effective amperes."

"Go on; what are effective volts and effective amperes?"

The engineer searched his partly confused brain. Then he got his pad and scribbled as follows:

effec. volts = 0.707 × max. volts
effec. amps. = 0.707 × max. amps.
effec. watts = effec. volts × effec. amps.
effec. volts × effec. amps. =
0.707 × max. volts × 0.707 × max. amps.

and submitted it to Jones.

"Correct," said that cheerful person. "Now multiply your two numbers together to make one factor of 'em."

So the engineer proceeded as follows:

0.707 × 0.707 = 0.5
effec. watts = 0.5 × max. volts × max amps.
" " = 0.5 × maximum watts.

"Well I'll be ——"

"You probably will, sooner or later," interrupted Jones. "Now, get a move on you and follow out the power-factor business. Effective watts are equal to ——?"

"Half of the maximum watts."

"Then in the two diagrams and the table the effective positive power is what?"

"Half of forty-eight thousand nine hundred and eighty-three ——" scribbling on his pad —— "Twenty-four thousand four hundred and ninety-one and a half watts."

"Put it down on a clean spot. What's the effective negative power?"

"Half of thirty-five hundred and seventeen ——" more scribbling——"Seventeen hundred and fifty-eight and a half watts."

"Put it down under the other figure—that twenty-four thousand and something. Now don't you see that if the generator delivers power to the circuit part of the time and the circuit delivers power to the generator part of the time, the watts that get to the lamps and do work in the motors are the difference between the two?"

"It looks that way," admitted the engineer, thoughtfully gazing at the table and the diagrams. "But I don't get that power-factor thing yet."

"You're 'most there now," said Jones encouragingly. "Subtract the effective negative watts from the effective positive watts."

The engineer made the subtraction and showed the following to Jones:

24,491½
1758½
22733

"All right. Remember that's the real power—the true watts actually delivered to the circuit and requiring mechanical power to drive the generator. Now, the maximum voltage is one hundred and fifty and the maximum current is three hundred and fifty amperes; what is the *apparent* power in the circuit—the effective volt-amperes?"

The engineer made the following calculation:

350 max. amperes
150 max. volts
17500
35
2)52500 max. volt-amperes
26,250 effec. volt-amperes

"Twenty-six thousand two hundred and fifty volt-amperes; good. That, you understand, is what you mean when you talk about apparent power in a circuit."

The engineer nodded. "And the power factor's the real power divided by this," he said.

"You're on," said Jones, "figure it out."

The engineer divided 22,733 by 26,250.

"Eight hundred and sixty-six thousandths," he announced.

"Express that as a percentage and it's your power factor," said Jones.

The engineer fidgeted uncomfortably.

"What's the matter?" asked Jones.

"How do you express thousandths as a percentage?" asked the engineer.

"What does per cent. mean, baby?" demanded Jones somewhat impatiently.

"Per hundred," answered the engineer.

"Well, if you have eight hundred and sixty-six parts out of a thousand, how many is that per hundred?"

"One-tenth as much."

"Well?"

"Eighty-six and six-tenths?"

"Of course. Write it down in fractional form and you'll see it plain as the nose on your face."

So the engineer wrote:

$0.866 = \frac{866}{1000}$

and $\frac{866}{1000} = \frac{86.6}{100.0}$

and $\frac{86.6}{100} = 86.6$ per cent.

"Now," said Jones, "look at the table; tell me what the current is when the voltage is at its highest point?"

"At ninety degrees," said the engineer, following down the columns of the table with his finger, "the voltage is one hundred and fifty and the current is three hundred and three and eleven-hundredths."

"And your highest current is ——?"

"Three hundred and fifty amperes."

"All right. Divide three hundred and three and eleven-hundredths by three hundred and fifty and tell me the answer."

The engineer performed the division, hesitated, glanced at Jones and then went over the division again to make sure he was right.

"Well," he said, "it's the same as the power factor, but I don't see why."

"Just think what it means," advised Jones. "When you divided the momentary current that exists when the voltage is maximum by the maximum current, you got the same result as when you divided the true watts by the volt-amperes, didn't you?"

The engineer agreed that he did.

"Then it follows that *the power factor is the proportion of maximum current which exists when the voltage is at its maximum.* See?"

The engineer saw.

"Yes;" he said, "it's coming through slow. If the voltage and current were in step like this," indicating Fig. 3, "they'd reach the top at the same time, and you'd get all the power there was ——"

"Careful," cautioned Jones, "you get all the power there is anyhow, but the power used in the circuit is greatest when the voltage and current are in step. When they are not, the power is less because the product of momentary volts and amperes at any point in the cycle is less than it would be if they were in step."

"I can see that," said the engineer, "by lookin' at the thirty-degree point in this diagram," taking up Fig. 5. "The current's zero here at thirty degrees but if they were in step it would be something, anyhow—I dunno how much."

"Right you are," said Jones. "It would be one hundred and seventy-five amperes at that point. Now get your tables of sines, cosines and so on."

The engineer took a copy of Trautwine from his bookshelf.

"Find the cosine of thirty degrees," directed Jones.

"Nought, point, eight, six—well, I'll be hornswaggled," exclaimed the engineer, "that's the power factor of this diagram, too. How many more things figure out that way?"

Jones grinned.

"You knew that before," he said, "but you've forgotten most of your early training. How many degrees is the current behind the e.m.f. in that diagram?"

"Thirty."

"And the cosine of thirty degrees is nought, point, eight, six, six, isn't it?"

"Yes, and so's the power factor," said the engineer.

"Of course. The power factor of any circuit or machine is the cosine of the number of degrees by which the current lags behind the e.m.f. That is called the angle of lag, for mathematical convenience."

"But you just said the power factor was the proportion of maximum current that exists when the voltage is maximum," protested the engineer.

"So it is," said Jones. "Didn't you just figure it? That's the physical definition of it; this cosine business is the mathematical definition, and connecting the two gives you this rule: *The cosine of the number of degrees by which the current lags behind the e.m.f. is the proportion of maximum current that exists when the voltage is maximum; it is therefore the power factor.*"

The engineer gasped.

"That's an awful mixup of words to remember," he said feebly.

"Surest thing you know," agreed Jones, with bland indifference. "Don't try to remember 'em; put 'em down where you can get at 'em when you want to, sort of like a formula, so: Power factor is equal to cosine of the angle of lag; also equal to proportion of maximum amperes that exists momentarily when voltage is maximum."

"Well," said the engineer, writing the rule on the fly leaf of his copy of Foster's "Pocketbook," "I ain't quite sound on that angle of lag business."

"Give you that some other time," promised Jones, removing his heels from the engineer's desk and reaching for his data sheets.

"Wait a minute," said the engineer, pointing at the small loops in Fig. 5. "You didn't tell me how that negative power gets back from the circuit into the generator."

"That's another story and a long one," answered Jones, replacing the diagrams in his book, "and I've got to get over to Uniontown this afternoon. So long."

Railroad cars loaded with snow are not an unusual sight at crowded terminals where it is necessary to ship the snow out in order to dispose of it. One of the disadvantages of snow shipments has been the necessity of unloading the cars. The Illinois Central has, however, discovered a unique method of dealing with the unloading problem. They ship the snow far enough South to melt it on the way. The empty cars used in this manner are ready to bring coal back to Chicago on the termination of their Southern trip, so that the work of unloading the snow is dispensed with.

Storage Batteries in Alternating Current Stations

By W. H. Radcliffe

The storage battery from the very beginning of its commercial career in the early eighties has been a direct-current station adjunct, and only within the last decade has it become useful in strictly alternating-current stations. Its chief value in this important but rather unusual field lies in its reserve power being used as a protection against the failure in supply of the direct current used to excite the field magnets of the alternators. Although the direct-current dynamos used as exciters in alternating-current stations seldom go wrong, the increasing seriousness of an interruption in service makes it advisable to leave no stone unturned to insure continuous operation. Under modern conditions of everyday life an interruption of lighting or power current may produce public calamity; that is why central-station managers strive to provide against the possibility of even a temporary shutdown.

In the large power stations built within recent years the parallel and independent groups of coal compartments, boilers, pumps, engines, generators and switchboard panels have become characteristic features. Considering here merely the provision made for insuring against exciter breakdown, it might appear at first thought that the addition of one or two reserve direct-current machines would be preferable to installing the more expensive storage battery of equal capacity, and this would be the case where shutdowns of short duration would be tolerated, as in small power stations carrying light loads; but in a large station the reserve machines, if installed, would have to be kept in motion continuously in order to insure absolutely uninterrupted exciter service in case the regular exciters failed.

With a storage battery permanently "floated" across the exciter busbars, the instant an exciter breaks down the battery automatically comes to the rescue, so that the current supply is not interrupted at all. The exciting voltage may fall slightly on account of the drop in the battery when it first takes up the load, but the voltage can quickly be brought up to normal by adjusting the number of active end-cells or by means of the alternator field rheostats.

Storage batteries for use in the manner described may be of either the Faure (pasted plate) or the Planté type. The pasted plate retains its charge remarkably well where used only occasionally, costs considerably less and occupies less space than the equivalent Planté plate. Owing to its smaller weight and bulk, it is also cheaper to install.

Gas Power Department

Everything worth while in the gas engine and producer industry will be treated here in a way that can be of use to practical men

Compression and Expansion Ratios

By Cecil P. Poole

What is the compression ratio of a gas engine? What is the expansion ratio? Nearly every man operating one probably thinks he knows the answer until he "gets down to brass tacks" and starts to give it. The compression ratio is not the clearance percentage, nor the ratio of compression to admission pressures; nor is it anything else except a simple ratio of volumes. The expansion ratio is also a ratio of volumes.

Compression Ratio

If you measure the cubic inches of space in front of a piston when it is ready to begin the compression stroke, then measure the cubic inches of space between the piston and the cylinder head when the compression stroke is completed, then divide the larger volume by the smaller, the result will be the compression ratio. That is all there is to it. It is not affected by valve setting, mixture variation or any other adjustment unless the adjustment changes the length of piston stroke or the volume of the clearance space.

For example, suppose the volume under the piston shown in Fig. 1 to be 12 cubic feet and that the piston is forced downward until the volume under it is reduced to 2 cubic feet, as indicated in Fig. 2. Dividing the volume before compression by the volume after compression gives

$$\frac{12}{2} = 6$$

which is the compression ratio.

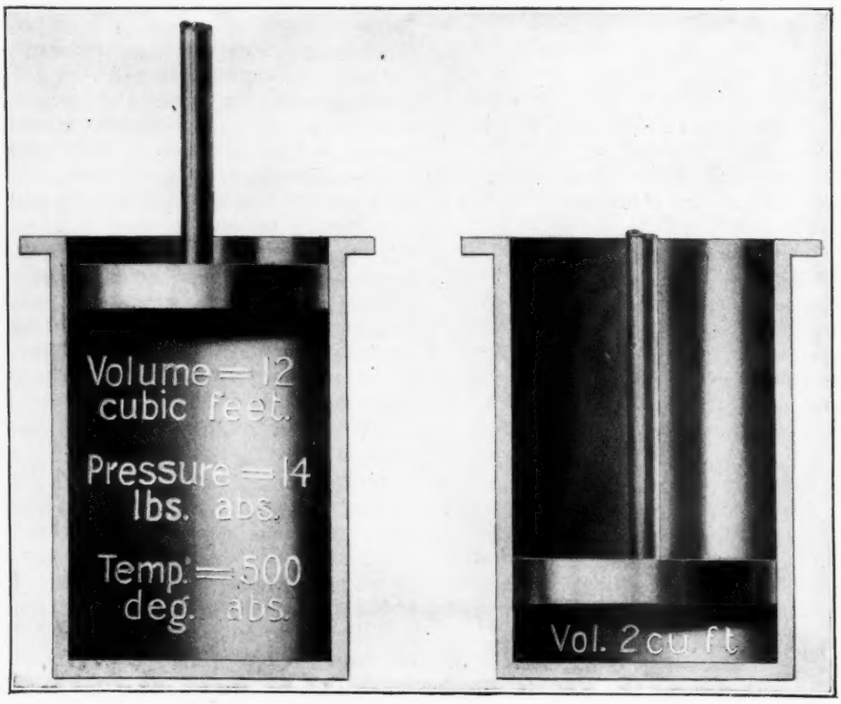


Fig. 1. Maximum Volume

Fig. 2. Compressed Volume

If the pressure in the cylinder is 14 pounds absolute (0.7 of a pound below atmospheric) before compression it will be increased to about 150 pounds at the end of the compression stroke, if no more heat escapes through the wall than is usual with gas engines. The temperature will also increase, but not so greatly as the pressure; if the absolute temperature is 500 degrees absolute before compression it will be about 900 degrees absolute after compression. But the pressure and temperature changes do not affect the compression ratio; they are *results* of it.

In the case just assumed, the compression ratio is 6, the pressure ratio due to compression is about 10.7 and the temperature ratio about 1¾. Under certain operating conditions, however, the pressure ratio could easily be 9½ or 10 and the corresponding temperature ratio 1.59 or 1.67, although the compression ratio would remain 6.

Expansion Ratio

If the exhaust valve opened at the end of the piston stroke instead of a little in advance of the end, the expansion ratio would be exactly the same as the compression ratio because the cylinder volumes at the ends of the stroke are the same in both cases. In other words, the volume of gases would increase exactly as much during expansion as it decreased during compression. If four cubic feet were compressed to one, then the one cubic foot would expand to four during the outstroke.

For example, if the cylinder in Fig. 2 contained a mixture of gas and air and the mixture were lighted with the piston in the position shown and the crank on the dead center, the pressure and temperature would rise rapidly—almost instantaneously. As soon as the crank passed the dead center the gases would push the piston outward, and if the exhaust valve opened wide when the piston reached the position in Fig. 1, at which compression began, the expansion ratio would be

$$\frac{12}{2} = 6$$

exactly equal to the compression ratio.

The exhaust valve does not open at the extreme end of the expansion stroke, however, and the expansion ratio therefore is less than the compression ratio in all modern engines working on the four-stroke cycle.

Fig. 3 illustrates this difference. At *A* the piston is shown at the beginning of the compression stroke; at *B* it is at the other end of the stroke, the crank then being on the opposite dead center; at *C*, just before the piston reaches the end of the outward stroke, which is indicated by the dotted line, the exhaust valve is supposed to open.

The volume in the cylinder at *A* (represented by the symbol V_a) is assumed to be 0.45 of a cubic foot; at *B*

it has been reduced by compression to 0.1 of a cubic foot, making the compression ratio

$$\frac{0.45}{0.1} = 4\frac{1}{2}$$

When the piston moves outward from the B position to that at C, where the exhaust valve opens, the volume V_c (0.1 of a cubic foot) increased to V_e, which measures 0.41 of a cubic foot. The expansion ratio, therefore, is mechanically

$$\frac{0.41}{0.1} = 4\frac{1}{10}$$

Effectively, it is a little greater because the exhaust valve does not open wide all at once and even when it is wide open the port is not large enough to allow

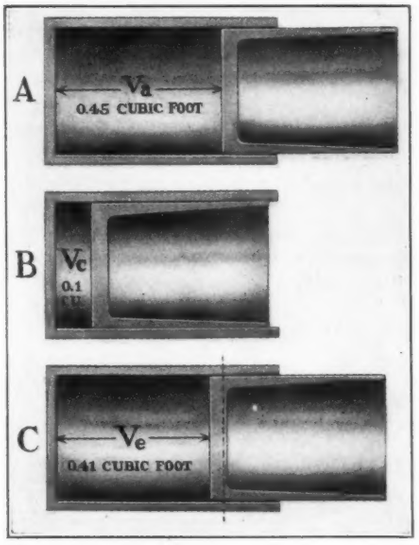


FIG. 3. ILLUSTRATING DIFFERENCE BETWEEN COMPRESSION AND EXPANSION RATIOS

the gases to fall instantaneously to atmospheric.

RELATION BETWEEN COMPRESSION AND EXPANSION RATIOS

However, the effect of the exhaust valve's movement may as well be ignored just now. The important fact to be remembered is that the compression and expansion ratios are "tied together," hard and fast, in the ordinary four-stroke engine.

Referring to Fig. 3 again, suppose the stroke of that engine were increased one-seventh. As it is represented here, the piston displacement is 0.35 of a cubic foot, the clearance being 0.1 and the maximum volume (displacement + clearance) 0.45 of a cubic foot. If the stroke be increased one-seventh without changing anything else, the piston displacement will be increased from 0.35 to 0.4 of a cubic foot. The maximum volume (displacement + clearance) will then be

$$0.4 + 0.1 = 0.5,$$

or one-half cubic foot, and the compression ratio will be increased to

$$\frac{0.5}{0.1} = 5.$$

If the exhaust valve opens when the piston has traveled the same percentage of its stroke as in the first case, the volume V_e will be 0.4543 of a cubic foot and the mechanical expansion ratio will be

$$\frac{0.4543}{0.1} = 4.543$$

as compared with 4.1 in the first case.

In other words, the expansion ratio in the first case was

$$\frac{0.41}{0.45} = 0.91$$

(or 91 per cent.) of the compression ratio; in the second case, the expansion ratio is

$$\frac{0.4543}{0.5} = 0.909$$

(or practically 91 per cent.) of the compression ratio.

The only way in which the relation between the compression and expansion ratios can be changed appreciably is by altering the timing of the exhaust-valve opening. If the exhaust valve opens in all cases when the piston has traveled the same percentage of the expansion stroke, the relation between the expansion and compression ratios must remain practically constant no matter what the compression ratio may be. With a compression ratio of 4 and the exhaust valve opening at nine-tenths stroke, the expansion ratio is 3.7, or 92½ per cent. of the compression ratio; with a compression ratio of 8, which is seldom if ever used, the expansion ratio would be 91¼ per cent. of the compression ratio.

In other words, the ratio of expansion to compression is only 1.35 per cent. smaller with a compression ratio of 8 than it is with one-half that ratio. Moreover, instead of obtaining a relative increase in expansion, which would give lower release pressure and temperature, the increase in expansion is less than the increase in compression, so that the pressure and temperature at release would be higher, notwithstanding the increase in the expansion ratio.

With the same compression ratio and the same exhaust-valve timing, the relation between the compression and expansion ratios is absolutely unchangeable, no matter what the size of the cylinder, relation of stroke to bore, or other features or conditions. It is impossible to obtain a greater expansion of gases unless the compression is increased and if that is done, the temperature and pressure of the gases at the moment of release will be raised.

EXAMPLES

To illustrate by figures instead of reasoning, suppose there were three gasolene engines, one 4x4 inches with a compression ratio of 3½, one 4x6 inches with the same ratio and one 4x6 inches with a ratio of 4. Further, suppose that all three engines work under the following conditions:

Pressure in cylinder before compression	13½
Compression-curve exponent	1.34
Rise of pressure due to combustion*	$.66 \times (r_c - 1)$
Expansion-curve exponent	1.3
Portion of expansion stroke completed when exhaust valve opens	⅞

A normal cycle in the three cylinders would work out about as follows:

Engine.	A	B	C
Bore and stroke	4x4	4x6	4x6
Piston displacement, compressing	50.26	75.4	75.4
Clearance volume	20.11	30.16	25.13
Compression ratio	3.5	3.5	4.
Compression pressure†	72.4	72.4	86.4
Rise by combustion	165	165	198
Maximum pressure	237.4	237.4	284.4
Piston displacement, expanding	43.98	65.97	65.97
Expansion ratio	3.2	3.2	3.625
Release pressure†	52.4	52.4	53.3

The comparison between A and B shows some of the results of increasing the stroke without changing the compression; the expansion ratio is not changed and, as the compression ratio is unchanged, the explosion pressure is also unchanged, giving exactly the same release pressure as before.

The comparison between B and C shows that increasing the compression by making the clearance smaller (the bore and stroke remaining the same) increases the expansion ratio, but it also causes the explosion pressure to go higher; consequently the greater expansion does not produce a lower release pressure. On the contrary, it is slightly increased.

The only way by which the expansion ratio can be made greater than the compression ratio is by making the compression stroke shorter than the expansion stroke. Although this is impractical mechanically, as the natural death of the Atkinson engine has demonstrated, the compressor effect of a shortened stroke can be obtained by holding the inlet valve open during the first part of the compression stroke and forcing some of the mixture out of the cylinder, or by cutting off the admission of mixture before the suction stroke is completed, as in the Sargent engine. Without the use of some such unusual method of operation the ratio of expansion must be slightly less than the ratio of compression in all engines working on the four-stroke cycle.

---

*The rise of pressure is greater with high compression than with low, because the proportion of fresh mixture is greater. The formula is based on the assumption that the clearance space remains filled with burned gases at the end of each cycle; r_c = compression ratio.

†Since the exponent of the compression curve is taken at 1.34 and that of the expansion curve at 1.3, the compression pressure is given by the formula

$$p_c = 13\tfrac{1}{2} \times r_c^{1.34}$$

and the release pressure by the formula

$$p_c = p_x \div r_c^{1.3}$$

When $r_c = 3\frac{1}{2}$, $r_c^{1.34} = 5.36$, and $13\frac{1}{2} \times 5.36 = 72.36$

When $r_c = 4$, $r_c^{1.34} = 6.4$, and $13\frac{1}{2} \times 6.4 = 86.4$

When $r_c = 3.2$, $r_c^{1.3} = 4.53$, and $237.4 \div 4.53 = 52.4$

When $r_c = 3.625$, $r_c^{1.3} = 5.33$, and $284.4 \div 5.33 = 53.35$

Readers with Something to Say

Practical information from the man on the job. A letter good enough to print here will be paid for. Ideas, not mere words wanted

Water Hammer Burst Valve

A serious case of water hammer, caused by carelessness, occurred in the boiler room of a Government building in Washington, D. C., some time ago, which burst a 6-inch angle-stop valve on one of the boilers, seriously injuring a coal passer.

Orders had been given to an extra man on duty to slowly fire up No. 1 boiler, which had been out of service several weeks for repairs, and at the time he went off duty 20 pounds pressure showed on the gage. The 9-inch header passes over the front of the boilers, each of which is connected by a 6-inch long bend with a gate valve, without a bypass at the header, and a 6-inch angle valve at the boiler, both of which were shut when the fire was started.

The gate valve is 4½ inches lower than the globe valve, and such is the arrangement on all the boilers, and it is supposed that the section of pipe between the two valves was partly full of water.

Soon after the extra fireman went off duty, orders were given to the coal passer, who, by the way, was an ignorant colored man and had only been employed in the boiler room a short time, to go up and open one of these valves. Instead of opening the angle valve as he should have done, he opened the gate valve about two turns when a violent water hammer was heard by the fireman, who told him to shut the valve, but for some reason he opened it wider and the second or third hammer burst the angle valve, as shown at *A* and *B*, the unshaded portion being the shape of the piece that was broken out of either side. The coal passer was knocked off the boilers and badly bruised and burned.

All of the boilers were connected to the header in the same manner, as shown in the figure, and without a bypass or bleeder between the valves.

In cutting out a boiler it has been customary in this plant to close both valves on the branch and to open the angle valve when the fire is first started to raise steam, but in this case it was overlooked by the fireman and the boiler was cut into the line by means of the gate valve. Even with the angle valve open the pipe will not drain, because it is 4½ inches lower at the header than at the angle valve. This leaves a pipe full, or nearly so, of water, the result being that the water goes into the steam line when the gate valve is opened and there is danger of breaking the 9x9x6-inch tee. The gate valve should never be closed except in case of emergency or repairs to the angle valve and the boiler should be cut in by means of the angle valve only.

J. Case.

Hyattsville, Md.

Connecting Ammonia Compressors

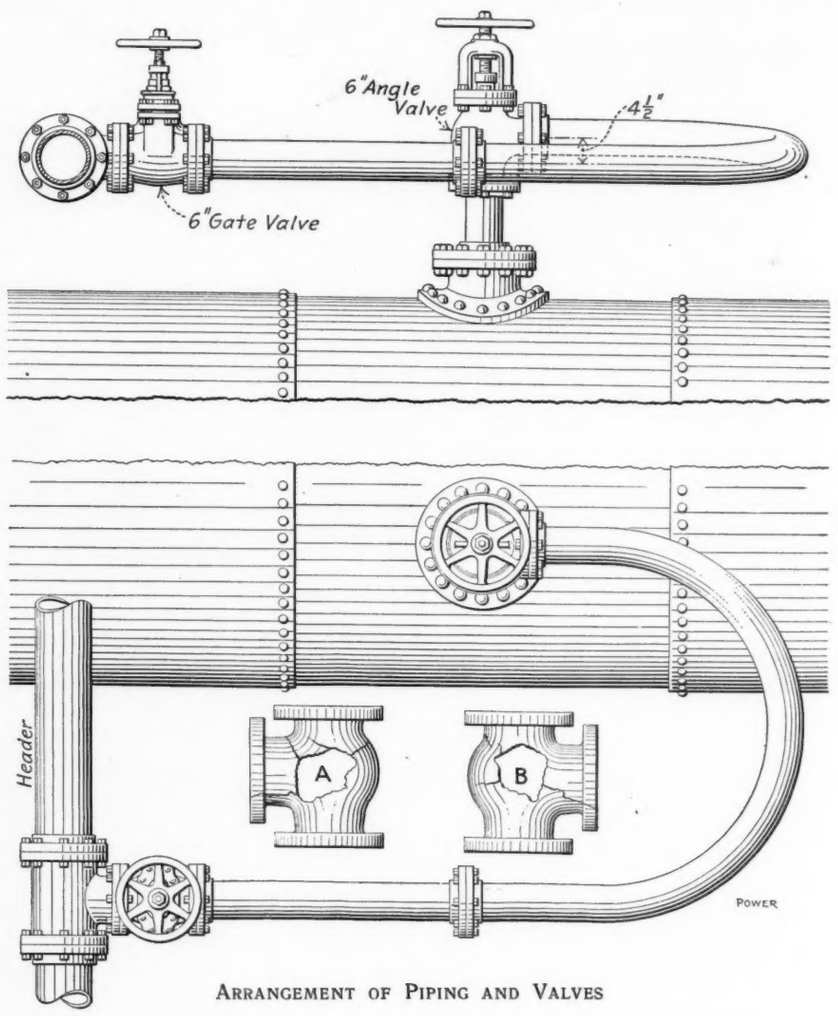
I am engineer in a refrigerating plant and a consulting engineer advised me to connect a 50-ton and a 35-ton machine to one condenser.

The large machine compresses through a 2-inch, three-way valve into a 2-inch header; the coils are also of 2-inch pipe. The small machine has the same size discharge pipe expanded into a 5-inch header at the condenser and does better work than the large machine.

Will these machines do good work if they are connected to the same condenser through the 2-inch, three-way valve? The condenser has a capacity of 54 cubic feet.

H. S. Free.

Harrisburg, Penn.

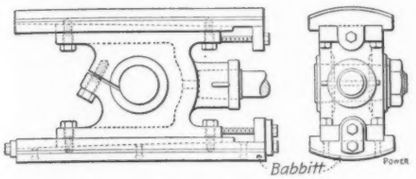


Arrangement of Piping and Valves

Loose Crosshead Shoe

The crosshead shoe of a large steam engine worked loose one night while the engine was carrying the peak load. As this was the main engine it was necessary to repair it at once.

I disconnected the shoe from the crosshead and drilled six 1½-inch holes through the babbitt and shoe body, and countersunk the holes in the babbitt with a drill ground for the job. Next, some copper rivets were made with which to rivet the babbitt to the shoe, as shown.



How Shoe was Fixed

To make sure of the job, two stops were made and fastened to the shoe, each overlapping the babbitt about ¼ inch.

This repair job proved very effectual and is still doing as good service as when repaired six months ago.

R. E. Cooper.

Cleveland, O.

Damper Regulators

I would be glad to hear from experienced engineers as to what has been found the best practice regarding the use of damper regulators.

In some cases, equipment of this kind is, no doubt, essential to good economy in boiler-plant operations and I would like to know what conditions would justify such an installation.

Some time ago, I consulted one engineer on this subject who stated that there are certain kinds of operation and conditions where regulators would be detrimental rather than otherwise, citing as an instance a boiler plant supplying steam to hoisting machinery where steam at a maximum pressure and volume is needed very quickly and at irregular intervals. He believed that a regulator in such a case would not operate quickly enough to be of any benefit.

Then, again, there are plants that supply steam to electric generating engines having constant loads where no great surges of steam occur and where there is no necessity for the safety valves blowing off.

I can readily see the advantage of proper damper regulation where there are a number of steam consumers scattered throughout a plant driving mill machinery that has varying loads and that uses a maximum amount of steam only intermittently. In such a case it would be rather difficult to maintain a constant steam pressure in the boilers without such an equipment.

Frederick Everard.

Pittsburg, Penn.

Boiler Setting and Steam Jet

I would like to know the opinion of engineers regarding my boiler setting which is illustrated in the accompanying sketch. Could I burn anthracite coal with any degree of economy? Run-of-mine coal is used and the analysis shows 12,000 B.t.u. per pound; it costs $2.70 a ton, delivered at the plant. Anthracite pea coal will cost $5.40 a ton, delivered, or double the cost of bituminous. Will a ton of the Pennsylvania anthracite pea coal produce as much heat as a ton of bituminous run-of-mine coal?

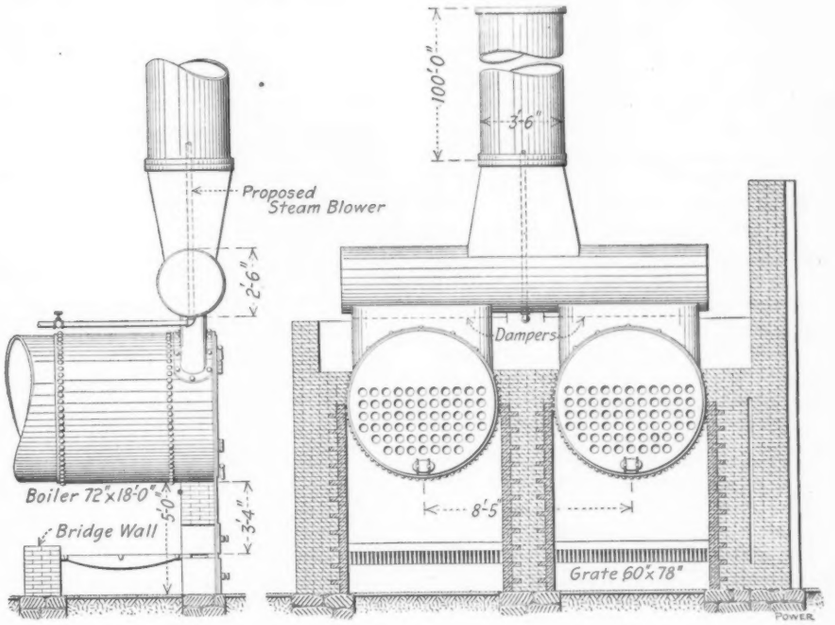
There is not much chance to make a saving in fuel, as the plant only operates about three months each year; but as the factory puts up a food product, I would like to burn anthracite coal so as to do away with the smoke, soot and dust of bituminous coal.

I would also like to see suggestions published on how to keep a boiler room clean. I use a tube blower, and it does good work as far as cleaning the flues is concerned, but it blows soot and fine ashes all over the room every time it is used. Our fronts do not fit very tight and I thought possibly a good steam blower in the stack would create enough draft to overcome the trouble. If so, how large should the steam pipe be; should it have a jet around the nozzle the same as the exhaust on locomotives, or will the nozzle in the uptake be sufficient?

I have a large, well ventilated boiler room and I like to see things kept neat and clean, but I want to see the fireman have time to read or otherwise employ himself instead of cleaning house all the time. I do not have to crowd the boilers. When the plant is working up to capacity, I burn from 10 to 12 tons in 24 hours.

F. B. DeMotte.

Washington, Ill.



Showing Boiler Setting and Steam Jet Arrangement

Scale in the Exhaust Pipe

There is a large open heater in the plant I am in charge of, that is fitted with the usual baffle plates for the water to flow over. The exhaust entrance was about midway between the heads and discharged to the atmosphere through a 6-inch pipe.

Soft scale collected very fast in the heater and had to be thoroughly cleaned out once a month. An overflow pipe connected at the bottom and extended above the water line. In case of a back pressure in the heater the water would blow out of this pipe as soon as the scale began to form in the openings through the heater. If a sudden, heavy load was thrown on, the water would overflow; cleaning the heater would always eliminate this trouble until the last cleaning, when it failed.

The top plate in the heater was so near the top of the opening in the heater that the exhaust outlet could not be seen, and the exhaust head prevented one from seeing into the other end. After closing down at night, I went inside the exhaust head and put my hand into the 6-inch pipe and found it partly closed with scale. I took the pipe down the next Sunday and found that the scale had reduced the pipe opening to a 3½-inch hole from the bottom to the top.

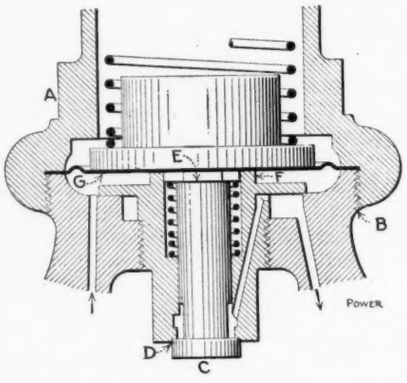
E. W. Smith.

Los Angeles, Cal.

Reducing Valve Trouble

I once had occasion to overhaul several reducing valves which had been in use a long time. The valves were taken apart and cleaned and valves and seats reground. After reassembling them they were tested and all worked nicely with the exception of two which would not reduce the pressure in the least. These two were taken apart again and seemed to be all right, but upon a second trial they still refused to work.

With steam on the valve a wrench was put on the bonnet *A*, which was unscrewed a little, when the valve started



SECTIONAL VLEW OF REDUCING VALVE

to work as it should, but steam escaped from the joint *B*.

After a little thinking I took the valves apart again and found that repeated grinding of the auxiliary valve *C* had worn down the seat *D* so that the nut *E* projected to far above the shoulder *F* and when the bonnet *A* was screwed down tight the diaphragm *G* would force the auxiliary open and hold it open, thus preventing the reduction of pressure.

The top of the nut *E* was filed enough to make up for the metal removed at *D* and the valves then worked satisfactorily.

MYRON D. PLACE.

Foxboro, Mass.

Loose Stud Caused Click

A Corliss engine in a factory had an unaccountable click in the cylinder for a long time. Various conjectures were offered from time to time as to the probable cause.

It was not until a breakdown occurred, however, that the real cause was found.

A stud had broken off in the piston at the end of the threads, tearing about two inches of its length loose in the hole.

Apparently a little bur was all that held the loose stud from dropping out of the piston into the cylinder as the engine passed over the head-end center. It would come partly out during the travel of the piston toward the crank center; then, upon the reversal of the piston travel, it would slip back to place, making the mysterious click.

The crisis came at last when the supposed bur wore away and the stud dropped into the cylinder. The cylinder head was not knocked out, although the engine was considerably damaged. The loose stud lodged in the exhaust port where the lower edge of the piston struck it and bent the stem. The piston rod was also too badly bent to be packed steam tight.

EDWARD T. BINNS.

Philadelphia, Penn.

Preserving Bolt Heads

A good substitute for expensive brass heads for bolts, where chemical action prevents the use of iron, has been found in babbitt.

A mold is made and a rack to hold the bolts in a vertical position. The babbitt is then poured around the iron head and allowed to cool.

F. H. STACEY.

Montreal, Can.

Dash Pot Troubles

I have frequently seen the question asking why a Corliss engine will govern perfectly with a normal load, but will race more or less when the load is light. The answer usually given is that the governor is not properly adjusted.

This trouble occurs more frequently with engines equipped with multi-ported valves, and the trouble is due to the action of the dashpots and not to that of the governor. A Corliss dashpot must lift quite a distance in order to produce sufficient vacuum to close the valve quickly. In the single-ported type, the valves usually have much more lap than the multi-ported valve, and in order to open the valves the dashpot plunger must be lifted about 9/16 inch with a 30x48-inch engine. In a multi-ported engine of the same size the lap will frequently be not more than ¼ inch.

A dashpot plunger must ordinarily lift at least ½ inch in order to produce a prompt cutoff. If the plunger does not drop its full stroke the valve will remain slightly open until the hook returns to pick up for the next stroke, when the valve will be closed by the hook pushing down on the dashpot rod. Of course, so long as the steam port is open, steam will follow the piston and the engine will race.

Multi-ported valves are more prone to leak than single-ported valves, on account of the smaller amount of lap. It is quite evident that the more lap a valve has the less will be the leakage.

I have sometimes thought that where an engine runs under a very variable load and a condenser is available that it would be a good plan to connect the vacuum chamber of the dashpots to the condenser, having check valves in the connections so that the dashpots would operate when the condenser was shut down. This would give a pretty constant pull on the dashpots; regardless of the lift. This scheme could only be applied where the dashpot has a cushion chamber separated from the vacuum cylinder.

C. A. GREEN.

Cleveland, O.

Regrinding Valves

A short time ago it became necessary to reface the valve seats in a boiler-feed pump, as they were badly pitted. As the reseating machine could not be used

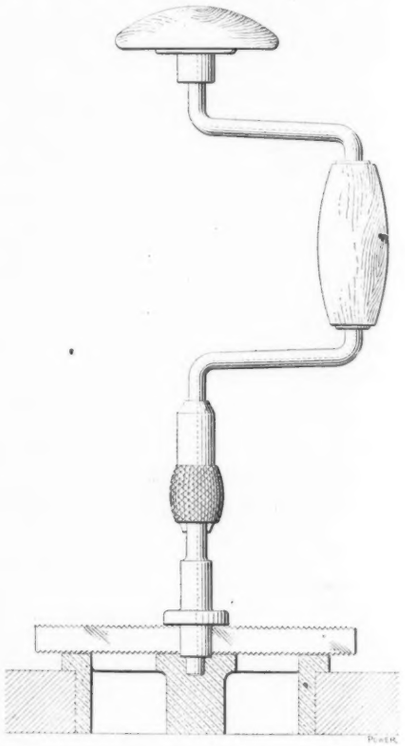


FIG. 1. REGRINDING A VALVE SEAT

on the valve decks without some kind of special rig to hold it, the method described herewith was tried.

A second-cut-file was annealed and a piece cut off a little longer than the diameter of the valve seats. A hole, the size of the valve stud, was drilled and tapped in the center to hold the spindle which went into the stud hole. Then I hardened the file cutter. The spindle fitted in the

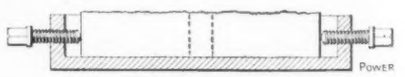


FIG. 2. WORN VALVE IN HOLDER

hole in the cutter and was held in a bit stock at the other end. The cutter was turned, thus facing off the seat.

I then thought that truing up the valve would help, so a holder was made, as shown in Fig. 2, which is a box fitted with a set screw to prevent the valve from turning. The box is held in a vise while the valves are being faced.

D. F. CROWTHER.

Boston, Mass.

Questions Before the House

Comment, criticism, suggestions and debate upon various articles, letters and editorials which have appeared in previous issues

Leakage through Piston Valve

I read with interest the articles discussing the report published in the October 11, 1910, number of the piston-leakage tests by Mr. Mitchell. I agree with Mr. Schoemaker in the January 3 issue that the pressure-plate valve leaks as much as, if not more than, the piston valve.

In the January 11 number, Mr. McGahey gives further examples of valve leakage. I think that Mr. Schoemaker and Mr. McGahey have lost sight of the fact that the amount of leakage through a valve when it is in a state of rest is much less than when it is in operation, and such a test, while showing the presence of valve leakage, does not indicate the amount under operating conditions.

Those interested in this matter may refer to *The Engineer* (London) for March 24, 1905, page 289, in which is given a report of the Brush Steam Engine Reseach Committee. It is there stated that the leakage through a slide valve is independent of the speed, but directly proportional to the difference in pressure on the two sides and that in most cases with perfectly balanced valves, the leakage is even greater than 20 per cent. of the steam entering the engine.

ASA P. HYDE.

Binghamton, N. Y.

Engineer and Machine

I differ with some points in the editorial in the February 14 issue entitled "The Engineer and the Machine." I wish to defend the supervising engineer—the "peripatetic supervisor." According to present practice the supervising engineer is engaged principally in looking after the operation of small private plants when there is no one who corresponds to the consulting mechanical engineer or the superintending engineer of the large power house or industrial plant. The only reason why he is "peripatetic" is because one private plant alone does not offer enough work *in his line* to keep him busy.

There are good men and bad. This applies to supervisors as well as to any other class of men. He who comes around and advises the boss that the engineer should be in line for a "cut" or is not needed at all is the one who is so set on "economy" that the plant will soon be on the high road to the scrap heap. This supervisor will sooner or later lose his job anyway, because he will become unpopular with the "boss."

There are honest supervisors doing business. Their work is to take certain responsibilities off the operator's shoulders and to help him bring the plant up in efficiency. If the supervisor and the engineer work together and realize that they can help each other and the boss better results can be obtained than were ever before dreamed of.

H. B. LANGE.

New York City.

Where Do You Stand?

An advertisement in a recent issue of POWER calls attention to a condition which is prevalent, judging from the evidence found in the advertising pages of all of the technical papers of the day. Briefly, the situation is this: A consideration, in the form of a "present," a "prize" or a "premium" is often used to influence the recommendation of the man who knows.

It reminds me of a story. We had changed from one brand of boiler compound to another and thought that we were getting better results when a salesman for the discarded brand dropped in and said that we had a condition which I would probably like to investigate after he had given me a tip.

I told him to unburden himself.

He said, "You know your engineer has been using our preparation with good results and now he has substituted So-and-So's and can give no good reason for so doing. I just want to tell you that it is a very common custom to pass a V or an X over the shoulder or under the coat tail to obtain desired results in selling boiler compound."

I replied that I knew that such things were done, but was not much interested. I had seen some literature sent out privately to engineers by a company which had an Eastern representative who was given a certain sum for advertising and who thought that the best way in which to advertise was to distribute the advertising money among the engineers in the form of presents, jewelry, etc.

Dismissing the salesman, I went down to see the old engineer. He hated me from the bottom of his heart, cordially and frankly, and I knew it and he knew that I knew it and neither of us cared; I also knew that he was honest and I would take a good beating rather than let anyone tell me that he was a crook. Nevertheless, I asked him if he was in the habit of accepting presents in consideration of his specifying any certain boiler compound.

He said, "No, but I just had a good chance to."

If your wife should go to the grocery and buy a pound of tea with a twenty-five-cent cup and saucer thrown in for sixty cents, she would get thirty-five cents worth of tea and that would be her business. If she should get a pound for her neighbor, keep the cup and saucer and give her neighbor the pound of tea in exchange for her sixty cents, there probably would be two women folks who would not speak to each other any more.

Enough said.

W. R. SMITH.

Alton, Ill.

Small Refrigerating System

I read with interest the communication of R. C. Turner in the January 31 issue regarding a small refrigerating system. He describes the refrigerant as "Picteau" fluid. Presumably, he meant the Pictet mixture of sulphur dioxide with 3 per cent. of carbon dioxide.

As all compression-refrigerating machines depend for their operation upon the same thermodynamic principles, and differ by only comparatively small amounts in efficiencies when the various refrigerating mediums are employed, we may expect this small machine, of excellent mechanical efficiency, to produce refrigeration with an efficiency of 60 to 80 per cent. of that of the large machines, small machines being in general inferior to larger ones by some such ratios. The work required to make one ton of ice in the large ammonia machine being 2½ to 3 horsepower for 24 hours, this machine would hardly make 1 ton of ice for less than 3 to 5 horsepower; wherefore, we must conclude either that the 2-horsepower motor was grossly overloaded, or that Mr. Turner means to say that the machine produced a refrigerating effect equal to that produced by the melting of one ton of ice—commonly called "a ton of refrigeration." In that case, the horsepower developed by the motor would probably need to be 60 per cent. of 3 to 5, or say, 1¾ to 3 and, giving

the machine the benefit of the more favorable figure, we may conclude that the 2-horsepower motor was working, at least, something under its full rating.

Mr. Turner gives 12 kilowatt-hours as costing 36 cents, an evident rate of 3 cents per kilowatt-hour. As a 2-horsepower motor will hardly have an efficiency better than 80 per cent. at full load, we may calculate a probable electrical input of

$2 \div 0.80 = 2\frac{1}{2}$ *electrical horsepower,*

equal to 1⅞ kilowatts. Electricity at the rate of 1⅞ kilowatts for 24 hours would cost, at 3 cents per kilowatt-hour, $1.35, which is the power cost of the ton of *refrigeration,* not of a ton of ice, which would cost about

$1\frac{2}{3} \times \$1.35 = \$2.23.$

Adding the labor cost of 25 cents and a depreciation and interest charge of only 10 per cent. on a probable first cost of $600, equal to 6⅔ cents per day, we find the total cost of one ton of refrigeration to be $1.66 nearly, and of a ton of ice, $2.75.

Even at that, the machine furnishes refrigeration equal in cost to ice purchased at 8½ cents per hundred pounds ($1.70 per ton)—which ought to satisfy any reasonable man content with mechanical possibilities.

S. H. BUNNELL.

New York City.

Binding "Power"

I have just finished binding my 1910 copies of POWER according to the method described by Mr. Lambowin in the issue of January 10, except that, finding that his method did not produce volumes that would probably stand the service to which I expected to subject them, I reinforced them by putting two wire staples clear through each.

As it was difficult to punch the holes and put the staples through a whole volume at once I made a gage out of sheet iron by taking a strip as long as a copy of POWER and about ¾ inch wide and bending ⅛ inch over at one side and one end. I then punched holes through it so as to locate the staples about ¼ inch from the edge and about 1½ inches from the top and the bottom. With this gage I punched holes for the staples in each copy separately. The staples I made of No. 20 gage wire. I then strung the papers on the staples one at a time as I glued them together, beginning with the first copy of the first month and going right through to the last copy of the last month of the volume. I chose to put only two months' issues in a volume. After all were glued together I clinched the staples and put on the backs and covers as described by Mr. Lambowin.

After I had the binding completed I printed labels on the typewriter to put on the backs. These labels show the months and the pages in each volume and the volume containing the index is indicated.

G. E. MILES.

Salida, Colo.

Boiler Operation

I read in POWER for January 31 the "Confessions of an Engineer," by R. O. Warren. He states that fuel can be saved by cutting out one boiler and running the remaining ones with open drafts and dampers. I have had fifteen years' experience in firing and I wish to say that with more boiler room, and when steam can be kept with dampers closed, much more fuel is saved than when the boilers are strained to their full limit and when in order to keep the steam pressure the dampers have to be open all the time.

F. VAN VALKENBURG.

Chichester, N. Y.

Water Gages

I think that H. F. Heyrodt is too severe with C. R. McGahey in his letter in the February 7 issue under the above title. I do not think that Mr. McGahey meant that the water column should be set as shown in the sketch. His letter explains that the lowest water line should not be less than 3 inches above the top row of tubes. I may not understand Mr. McGahey's letter correctly, but I cannot find anything wrong with it.

Mr. Heyrodt considers the use of gate valves on water columns poor engineering; I consider the use of globe valves on water columns poor engineering, and no valves at all a great deal worse.

WILLIAM SWOPE.

Tiffin, O.

Homemade Belt Dressing

In the February 14 issue, Mr. Van Antwerp gives a recipe for making belt dressing.

I have had some experience with rosin as a belt dressing. It is efficient in making a belt stick to the pulley while it lasts. But, an application of rosin to a slipping belt will last only a short time. It has been my experience that where a leather belt is dressed with rosin it soon becomes hard and rotten and cracks and the holes where the belt is laced soon pull out. With canvas and rubber belting I never noticed any depreciating effects.

If anyone has a large, expensive leather belt that is giving him trouble, I would advise the use of some good oil, such as castor or neatsfoot. This makes the belt soft and pliable so that it conforms to the shape of the pulley and adds to the life of the belt.

EDGAR ALTMANN.

Cincinnati, O.

On Lending a Hand

The first-page editorials in POWER for January 17 and January 24 bear close analogy, they go hand in hand and are distinctly applicable to the element, found in all walks of life, that "isn't telling all it knows." Dealing with the power business, the engineer that gets "results" such as depicted in the later issue, the extremely "practical" man, who has little use for any literature regarding his profession, who scoffs at technical papers and sneers at the advertisements contained in them, is usually the one who "won't help the other fellow," and who is keeping all he knows to himself—as a rule, this is very little. This is the class that "knows it all." From the engineer of this type we learn much of "past performances," of what he has done and what he has been through and in full completion there is often a missing link, "how." But this is the secret, it fails to appear either because it is as much of a conundrum to himself as to the other fellow or because the other fellow might accidentally glean a kink. When anything goes wrong he is the one who is the quickest to blame it on another operator. I am acquainted with a very "practical" man who has adorned the engine room with a patent safe, a breadbox fitted with a padlock; into this is placed his "records and private data"; the desk, supplied by the company, is too public and the engineer on the following watch might see something. To have a motto, "Let the other fellow learn the way I did," isn't showing full appreciation of the fact that possibly you learned considerable from someone yourself; it must be excessively hard to go through life in this frame of mind.

To a man of character and business sense, there is nothing like extending a helping hand; because one man's experience is not on a par with another's, is no disgrace; none of us can ever know too much, and when we begin to realize that we can learn something, that we do not "know it all," it is the first signs of judiciousness. The young engineer, the man trying to make progress in his chosen profession, should be assisted and encouraged, not discouraged; when mistakes occur, he should be shown where he has erred, not taunted; he should be helped on, not held back. Nothing will have such a demoralizing effect upon the fellow trying to learn, as the man with the big head and infused with self-conceit; it downs him in his purpose and ambition, and makes him impressed with "What's the use"?

There is an old saying, "Chickens come home to roost," and its full significance should be understood. POWER points out that there is a feeling of great satisfaction to the man who knows he has helped another and there is certainly no comparison between this and that other sensa-

tion, "he didn't get any information from me."

L. R. W. ALLISON.

Los Angeles, Cal.

Specialists

I sometimes wonder, from the letters occasionally printed in these columns, if there are any experts alive. I often read letters from some dinky little one-horse engineer like myself telling how he had to put the bricklayers right with their mortar, etc., although probably the men had been doing boiler brickwork for years. Then, the machine erecters changed their plans when shown where they were wrong. Next, the men putting up the shafting were shown a point or two, and so on. Not one of these experts was right—at least, so our engineer will inform us at three "plunks" or so per column. Any right-minded man should know that such contributions must be from some gassy engineer spouting rot. No man is perfect, but the erecters and experts sent out by manufacturers seldom make many mistakes at this date.

To say that any man, even a chief in a first-class plant, is an expert in all branches of steam engineering is wrong.

C. F. Scott, of the American Institute of Electrical Engineers, said (in 1908) that if all the studies were included that had been suggested as essential or desirable in the training of an engineering student, the college period would need to be 30 years in length. This is 1911, so I guess it would mean 40 years by now.

Prof. L. B. Stillwell, in the same year, said that men who rise highest in the engineering profession, generally speaking, are the men of broader education. Employers have little trouble in finding draftsmen and competent calculators, but the demand for "all-round men" always exceeds the supply. Now, if he meant men with several college degrees and 10 or 15 years' practical experience, anyone would know as much without being told. But, if employers who require good all-round men, that is, men with good practical experience and some technical knowledge, will put a two-line ad in POWER, I venture to predict that they will get hundreds of answers from real good men, always providing that the salary is adequate for a good man, say $2500 to $4000 per year. Surely a man is worth that who has spent probably half a lifetime to make himself as proficient as possible.

JAMES SCOTCH.

Toronto, Ont.

Steam for Preventing Clinkers

Referring to the February 7 issue, in which Charles H. Parson makes comments in regard to the reply to a question asking if steam jets under the grates will prevent the formation of clinkers and if their use is economical practice, I think the answer which the editor gave to the question is as nearly correct as could be stated.

Mr. Parson's statement that ash does not melt at all is entirely wrong, and he contradicts himself by saying, "Clinkers are caused by the fusing of certain elements in the fuel. These elements may be sand, silica, sulphur, etc." If sand, silica, etc., are not ash, what are they?

It is generally believed that as steam passes through a fuel bed, the steam is decomposed into hydrogen and oxygen and absorbs heat from that part of the fuel bed where the decomposition takes place. The hydrogen formed from the decomposition of steam in the fuel bed is probably burned above the bed and, hence, the furnace temperature as usually measured may be very little different than that obtained when the steam jet is not in use.

E. G. BAILEY.

Boston, Mass.

Smoke Abatement

Henry D. Jackson, in a recent issue, offered his solution of the problem of smoke prevention. Several very good suggestions were given. He suggests the old coking method of firing for the prevention of smoke. But, how many men are there who are physically able to fire in such a manner; also, how many plants are there in which such a plan could be followed without losing the steam pressure? How can better results be obtained than by the spreading method of firing? Some of the most skilled firemen use the alternate method. Is it not true that the percentage CO_2 depends greatly upon the temperature of the fire; also, that greater capacity can be secured by firing lightly, evenly and often? Then, why do so many indorse the coking method when the spreading method is used in perhaps nine cases in every ten?

I certainly approve of paying a fireman all that he is worth. In addition, I am much in favor of the bonus plan. It engenders enthusiasm and vigilance which are kept up because the bonus must be earned, whereas an increase in wages only serves as a temporary stimulant.

WALDO WEAVER.

Middletown, O.

Burning Pulverized Coal

I was much interested in the article in a recent issue on burning pulverized coal. There were two items in the results of the test that seemed peculiar.

The duration of the trial was only six hours. This is entirely too short for a boiler test if any dependence is to be placed on the results.

The temperature of the flue gases as given, 386 degrees Fahrenheit, is extremely low when it is taken into consideration that the temperature of the steam at the pressure given would be about 371 degrees Fahrenheit, there being a difference of only 15 degrees in temperature between the flue gases and the steam. No mention was made of an economizer. An explanation of this temperature should prove highly beneficial to those of us who are interested in boiler economy, even if we do have to burn lump coal.

JOHN BAILEY.

Milwaukee, Wis.

Writers Among Engineers

As has been stated, the starting bar or a monkey wrench is a far handier tool than a pen in the hands of most engineers. To buckle down and compose a four- or five-hundred word article which will be rewritten two or three times before it is considered sufficiently good to trust to the tender mercies of the editor, and then go around in a cold sweat for the next two weeks expecting every mail to bring it back marked "N. G." or "not available," is more than most engineers can stand.

Some men write for the pleasure it gives them to lend a helping hand. Some write just to see their names in print. Others write for the money to be gained, which is very acceptable to all.

I find that there are from 20 to 30 articles in each issue of POWER which are from one-half to one and one-half columns in length each that I would take to be written by the men "on the job." I also find that the circulation is about 33,000. Suppose 13,000 copies go to libraries, professors, retired engineers, students, etc., leaving 20,000 to go to the men on the job. Of these 20,000 men there should be at least 10,000 who could write at least two articles per year on some accident, kink, saving, or what not that he has had to deal with during the year. This would give us a little over 380 articles per issue as compared with 25 or 30 now. Of course, such a number could not be used, but this shows what a small amount of writing it would take to make a rousing old paper out of our friend POWER.

I think that if the editor would give us a few front-page talks on the writing of articles, and the most acceptable subjects, going into detail on some of the points connected therewith, some of these days, very soon, such a pile of letters would drop at 505 Pearl street that someone would have to dig the whole office force out.

C. E. BECKWITH.

Sprague, Wash.

Indicator Diagram Defects

A suggestion in reply to Mr. Binns in the February 7 issue: Perhaps the piston is traveling past the indicator hole. I have had trouble of my own in this respect.

Also, was a spring of the right scale used?

J. L. KEZER.

Bradford, Penn.

Referring to the indicator diagram submitted by Edward T. Binns and published in the February 7 issue, when admission occurs at the head end, the pressure causes the indicator piston to rise abnormally high, due to excessive lead. As the piston is well balanced, that is, it moves with perfect freedom, the vibrations due to inertia are set up.

. The reason why vibrations are not present in the crank end is because there is not so much lead.

J. P. COLTON.

Ohio City, O.

The Position "Higher Up"

The question asked by Mr. Richmond in the February 14 issue is answered in the various editorials in POWER and in the little squibs tucked away in the corners of the pages.

I stepped out of the fire room into my first job as chief. How I did it may be interesting but I have always accepted it as a matter of course. I had been firing a pair of boilers for over three years and had got the trick down so fine that the boiler manufacturer noticed it and used to borrow me once in a while to fire boilers for him when they were under test. I always got as high an evaporation as the coal and boiler would stand and the boiler man always got his money.

While going out on these jobs, I noticed the men who were conducting the tests taking indicator diagrams. This interested me and, although I was working seven days a week and twelve hours a day for $40 per month, I managed to save enough money to buy a cheap indicator and to find time in which to indicate engines wherever I had acquaintances.

One day the mechanical engineer who built the plant dropped in as I was taking some diagrams from our engines. He looked at the diagrams and asked me if I knew what I had when I got one. I told him that I did and showed him some diagrams from about twenty other engines on which I had laid out the point of cutoff and the theoretical expansion curve. He seemed to be impressed and, after a while, told me that he had a pair of Corliss engines in another plant that were not doing very good work and that if I would set the valves and bring him diagrams, taken before and after setting the valves, all figured up, he would give me $20. I took a day off, indicated the engines, set the valves and spent the night figuring up the diagrams. The next day, I got an hour off and took the diagrams to him, got my $20 and went back to work at my firing job.

But that experience taught me something. There was a vast difference between $20 for a day's work and $20 for two weeks' work. So I got busy, saving money to buy books and more instruments and nearly had nervous prostration from studying and experimenting. I think the only time I ever lost from work, when I wanted to work, was at this time, when I had to go to a hospital to have my eyes treated and later on when I went to a hospital to get some burns treated which I received while trying to conduct a fire test of a sample of oil with a homemade flash pot and a gasolene torch.

Some time after indicating those two engines my mechanical-engineer friend came around and said that in a plant somewhat similar to the one in which I was firing the chief engineer was due to walk the plank. He asked me if I thought that I could handle the job. The wages were to be $21 per week, only five and a half working days per week. Although the offer nearly took the breath out of me, I told him that if he was willing to try me I was willing to take a chance and that if I failed it would not be because I had not tried.

The long and short of it is that he gave me the position, and I have held that and similar positions almost without interruption ever since.

One of the principal requirements of a chief engineer is executive ability and this is hard to acquire. Another qualification is fair bookkeeping ability. I studied probably all of the technical journals for ten years and could figure out any of the problems relating to a stationary engineer's work. Then I saw a new light. Today, I do not believe that I could figure out the horsepower of a boiler or engine or do any of the lever safety-valve problems without consulting a book. But, I can figure out the cost per kilowatt-hour of every item entering into the daily operation of the plant, lay out the load curve, figure the load factor and the boiler performance, show the difference between the last twenty-four hours' operation and that of the preceding day and account for that difference. Any or all of the foregoing information I can put on the manager's desk by ten o'clock in the forenoon. Such things are what really count and are what the company wants.

I am not a paragon of virtues and meet engineers every day to whom I take off my hat. In fact, I have had them working under me and have in several instances managed to turn over my job to them when I got ready to quit. I never noticed an engine-room clock except to see that it was correct and still running, for I always considered that I was paid for twenty-four hours per day. I have always respected my employer if I did not respect the man. I have never asked for a raise in salary in my life and my employer has always paid me *all* of the salary I received.

I work hard and long and expect the men and machines under me to operate at as near full capacity as possible. In return for the coöperation of the men, I see to it that they get all the money that the company will stand for and I do not work them on twelve-hour shifts. It may sound strange, but I have found that a sure way in which to bring down the cost per kilowatt-hour, and that is all that I think and dream about, is to see that the men get all the money within reach and work short shifts.

EDWARD ADAMS.

Reading, Penn.

Under the above head in the issue of February 14, Oscar J. Richmond wishes suggestions on the matter of obtaining better positions.

It is generally admitted that the first move is self-education, which results in increased personal efficiency. A difficulty mentioned, and it is a real one, is the fact that a power-plant engineer is tied down for the greater part of every day with a minimum chance for meeting influential men and thus furthering his ends. He has, however, the same use of the United States mails as his employer. All "improved" engineers are conscientious readers. In reading they are continually noting the affairs of others and news with regard to new undertakings. If in search of an opening, many ideas should be gleaned in this way. New power plants in the course of construction will soon need engineers. Improvements in old plants will need better talent. New companies forming will need expert talent. A card index or other means of tabulating should be instituted and business methods applied to the subject in hand—that of getting a better job.

Letters should be written by the dozen and the replies graded as to prospect. It must be remembered that letters are proxies and as such should truly represent the writer. A slovenly letter may not always indicate a slovenly man, but in the absence of other evidence the effect is the same. The rent of a typewriter would amount to a few dollars a month, and a little practice makes one fairly proficient. And if the end is worth having at all, the typewriter is a part of the job-getting business. Another way would be to turn the letters over to a friend who is a stenographer, or still another, have them copied by a public stenographer. In the quest of a position, do not send a letter written in long hand to a stranger; in most cases it is suicidal.

Blind advertising is all right in the search for men, but as a means of ob

taining a position it is practically useless. The head of a plant has too many opportunities to reach people directly, and the blind advertisement carries with it an atmosphere of distrust.

Engineering societies and clubs do much to raise the standing of men who take active part. There are those whose fortunes were made by this method, sometimes called "self-advertising."

Above all things, if you really want a new job, go after it in a whole-hearted manner. You cannot leave a stone unturned and do justice to yourself.

L. F. WILSON.

Chicago, Ill.

Binding "Powers"

In the February 7 issue, Mr. Levy tells how he takes care of his copies of POWER.

I have been a regular subscriber to POWER for a number of years and I have every copy that was ever sent to me. I have a case in the engine room for them; in it I place each copy after I have read it. I can get any number I want without the slightest trouble. I keep the titles of such articles as I need in a ledger. I think I have a better method than any I have seen described.

E. O. FOULK.

Pioneer, La.

Vacuum for Reciprocating Engines

I take exception to the opinion expressed in the article under the above in the issue for January 31. The old-fashioned and impractical idea of 26 inches of vacuum being the limit for economical engine performance should be discarded with the innumerable other practices now obsolete in engineering.

Why should the author, as is customary with engineers discussing the subject from the same viewpoint, base his figures on the steam delivered to the low-pressure cylinder? If the steam requires more volume with the higher vacuum than is provided in this cylinder, why not change the cutoff in the high-pressure cylinder and adjust the receiver pressure accordingly? The decreased back pressure will allow of a shorter cutoff for the same power output. After putting the condensing apparatus into first-class shape and obtaining the highest vacuum possible, the valve setting should be adjusted to correspond. In some plant-betterment work, which I conducted recently, the vacuum for the engines was changed from 25 and 26 inches to 27 and 28 inches with marked improvement in the coal consumption per kilowatt-hour. The dashpots in several cases acted badly under the new conditions but the trouble with the *dashpots* was eliminated by better adjustment.

Parallel with this mistaken idea is the practice in many plants of dropping the steam pressure during the light load at the noon hour. The reason for this generally is on account of the poor regulation under the lighter load with the short cutoff. There is no excuse for this in a reputable engine and it will usually be found that a better adjustment of the governor, dashpots and valve gear will eliminate the trouble.

Let us forget obsolete practices!

THOMAS J. WALSH.

Boston, Mass.

Change of Cutoff

In a recent issue a correspondent wanted to know how to change the cutoff of a Brown engine.

The engine takes steam while the valve is going up. If the engine will stand a little more lead, a later cutoff will be obtained by increasing the lead, and an earlier cutoff by decreasing the lead.

I have an idea that the engine is overloaded and that a little later cutoff is desired.

H. JONES.

Wylam, Ala.

Central Station vs. Factory Plant

The instances of greater cost of power obtained from central-station current than of power produced by the independent factory plant cited by Henry D. Jackson in the issue of February 14, are but examples of scores of cases where the central-station agent would "never have gotten further than a look in" had the owners gone to the small trouble and expense of having a disinterested examination made of the actual conditions and of the possibilities of saving power, or money, by changing from the belt drives of a factory plant to electrical power and transmission. Saving of space, greater cleanliness and greater convenience are advantages possessed by electric power and transmission over the ordinary factory-plant belt drives that can be turned to good account in almost any manufacturing establishment; but the power which will be saved by the elimination of belt transmission is usually much overestimated.

Electric-line losses and losses due to imperfect insulation of motors rarely amount to less than 5 per cent. and, placing the average working efficiency of motors at 85 per cent., it can be seen that the electrical horsepower read at the switchboard must be about 20 per cent. in excess of the net power delivered by the motors.

From an experience of testing many hundreds of factory plants, I can testify to the fact that shafting friction in nearly all lines of manufacture has been found to be nearer 10 per cent. than 20 per cent. of the total power required, in many cases being less than 10 per cent. of the power that would have to be delivered to the same points by motors.

In the average factory, shafting, pulleys and belting are the most conspicuous features of the power plant, and to the uninitiated they are impressive of the idea that they absorb most of the power required for the whole establishment. It is no wonder that owners are profoundly impressed with arguments of savings of power that are to be realized by the employment of electrical transmission, especially if they are not "wise" to losses that are inevitable in the conversion of electrical power at the switchboard into actual power.

In a case where it is proposed to change from belt transmission to electric driving and where cost of power is a consideration, it will pay to make careful tests to determine the power lost in transmission, and it is of equal importance to demand guarantees of motor and line efficiencies. The loss or saving resulting from the installation of electric motors can then be determined in advance in place of waiting until after the central-station service bills are presented and the plant has been equipped with a list of expensive motors.

Quite recently I was called in to consider a case where the proprietors of a plant were greatly disappointed to find that the central-station charges for current supplied to the motors amounted to nearly double their former cost of power generated by the old factory plant. Enormous savings had been looked for. Transmission by belts had been replaced by electric motors installed in groups, main belt drives abandoned, a good Corliss engine power plant shut down, the engineer discharged and only a fireman retained for making the steam necessary for the manufacturing processes and for warming the buildings with live steam.

The only improvement was in one department where the speed was more uniform than formerly. In this case the old transmission had been by vertical belt and the condition of the lower pulley showed that slippage took place on account of the belt dropping away from the driving pulley, a trouble which any millwright engineer would have corrected by giving slope to the belt or by employment of a ready-made belt tightener for less than 5 per cent. of the cost of the new electrical equipment. In this case electric motors were employed for driving the old line shafts. The only transmission that had been displaced was the jack shafts which I am satisfied could not have absorbed more than about 5 per cent. of the power which they transmitted.

This was a case where the claim of saving power by electrical transmission was absurd and the central-station rates will have to be materially reduced in order to meet the cost of operating the old plant.

FRANKLIN VAN WINKLE.

Paterson, N. J.

Inquiries of General Interest

Questions are not answered unless accompanied by the name and address of the inquirer. This page is for you when stuck—use it

Horsepower of Gas Engine

Is there a formula for estimating the horsepower developed by a gas engine?

E. D. R.

For a four-stroke cycle engine using illuminating gas or gasolene the output that will probably be obtained is given by the formula:

$$\frac{d^2 s n}{12{,}500} = \textit{horsepower}$$

in which

d = Diameter of piston in inches;
s = Length of stroke in inches;
n = Number of revolutions per minute

For a two-stroke cycle engine use 8000 instead of 12,500 for the divisor.

Pressure Required to Compress Air

What pressure per square inch will be required to compress air to ⅔ and also to ½ its original volume?

P. C. A.

The volume of a gas varies inversely as its pressure and the product of pressure into volume is constant, provided the temperature remains constant. To compress a given volume of air to ⅔ of the original volume will require ⅔ of the original pressure and to ½ the original volume will require twice the original pressure. If the air to be compressed is at atmospheric pressure the pressures will be

$3/2 \times 14.7 = 22.05$ *pounds absolute*

and

$2 \times 14.7 = 29.4$ *pounds absolute*

respectively.

At any pressure other than that of the atmosphere the method will be the same.

Efficiency of Boiler and Furnace

How is the efficiency of a boiler and furnace determined?

E. O. B.

By dividing the heat transmitted to the water by the heat in the fuel.

Brass and Babbitt Bearings

Which is better for engine-shaft bearings, brass or babbitt metal?

B. E. B.

Under all ordinary conditions babbitt metal is preferable.

Dead Weight Safety Valve

What is a dead-weight safety valve?

D. W. S.

It is one in which the valve is loaded by weights acting directly on the valve without the interposition of a lever.

Cause of Reversed Rotation

What would cause an engine to run backward?

R. C. R.

A sufficient change in the position of the eccentric.

Point of Cutoff

At what point in the stroke will cutoff take place in an engine of 20 inches stroke, valve travel 5 inches and outside lap 1⅜ inches?

P. O. C.

The point of cutoff will vary slightly with the lead. With 5/16-inch lead the period of admission will continue through 62 per cent. of the stroke.

$20 \times 0.62 = 12.4$ *inches*

With no lead, cutoff will occur at 66.6 per cent. of the stroke.

$20 \times 0.666 = 13.32$ *inches*

A valve having the lap and travel as stated would give a port opening of 1⅜ inches.

Pohle Air-lift Pump

Will you please explain the construction and operation of the air-lift pump?

P. A. L.

The air-lift pump consists of a vertical water pipe the lower end of which is submerged in the water of a deep well, and a smaller pipe delivering air into the lower end of the water pipe. The air rises in bubbles, and the column of air and water inside the pipe being lighter than the solid water outside, it is forced upward by the unbalanced pressure.

Vacuum Gage on Suction Line

Kindly explain the theory and use of a vacuum gage on the suction line of a cold-water pump. Is it proper to locate the gage on the suction gas chamber? Will its showing be the same there as on the main suction line? Explain the gage reading; what it should read on, say, a 20-foot suction lift, and what information does the engineer get from the reading that is of practical use to him in operating the pump?

G. S. L.

A vacuum gage on the suction pipe from a pump may give much or little information to the pump operator, depending entirely on the conditions under which the pump is working. Attached near the pump it tells the vacuum required to draw water to the pump at all times. With clean water and steady service this may not be much, but with the suction pipe drawing water from a source filled with seaweed, dead leaves or grass, the strainer may become clogged and the vacuum gage tells that the supply is being restricted long enough before the pump fails to allow for cleaning. It is proper to attach the gage to the suction chamber, and it will read the same as though attached to the main pipe near the pump; but the farther from the pump it is attached, the lower the reading will be. With a large suction pipe and a slow running pump, the gage should read 18 inches for a 20-foot lift, but with a long pipe with numerous ells and with the pump running at a high rate of speed, it may read as high as 28 inches.

Factor of Safety of Old Boilers

What rule is followed by boiler inspectors in reducing the working pressure on horizontal tubular boilers with lap seams on account of age?

T. M. D.

Boiler inspectors follow no general or regular rule in reducing the allowable working pressure on a boiler due to its age. They rely upon their judgment and experience. The Board of Boiler Rules of the State of Massachusetts prescribes that the lowest factor of safety used for boilers, the shells or drums of which are exposed to the products of combustion and the longitudinal joints of which are lap-riveted construction, shall be

5 for boilers not over 10 years old;
5½ for boilers over 10 and not over 15 years old;
5¾ for boilers over 15 years old and not 20 years old;
6 for boilers over 20 years old.

These factors are considered by many engineers to be altogether too small, and that 6 should be the lowest factor of safety allowed on a new lap-seam boiler and that the factor should be increased each year to such an extent that it will put the boiler out of use at the end of 10 years.

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POWER

Reduced Grate Area at Light Loads

It is generally conceded that with a properly designed furnace the highest grate efficiency is obtained when burning the maximum amount of coal per square foot, consistent with complete combustion. Opposed to this, however, is the efficiency of the boiler itself. With a fixed heating surface, increased combustion is accompanied by a higher stack temperature and this means increased heat losses. There is a mean between the boiler and the furnace efficiencies and in good design this point should represent the rated capacity. Boilers are often forced considerably beyond their ratings, with only a slight loss in economy, but this is explained by the introduction of other factors, such as increased velocity of the gases, etc.

On the other hand, through lack of judgment or to meet certain conditions, boilers are often installed having a rated capacity far in excess of the load to be carried. In such cases it is customary to reduce the draft to suit the load; this results in more or less incomplete combustion and tends to lower the efficiency of the unit. Here it would be much better to reduce the grate area and maintain a high rate of combustion. Instances are on record where this has lowered the fuel consumption as much as five per cent.

The Cost of Power

To one who got his knowledge and impressions of the subject from the recent joint meeting of the American Institute of Electrical Engineers, and the American Society of Mechanical Engineers, the man who runs an engine and generator when he can buy current from a central station would appear a blithering idiot.

It is not surprising that a meeting, all of the papers for which were written by central-station men and most of the prearranged discussion prepared by their friends, should have turned out so preponderatingly and exaggeratedly one sided as to have excited the risibility even of central-station sympathizers; but it is surprising that the managements of the societies involved should have turned the forum of American engineering into an arena for the mental gymnastics of the central-station distortionist; and the "proceedings" of a great national professional society into a reference book for him who seeks to justify high rates.

To the engineer whose interests are not involved with those of the central station it is quite possible to conceive a condition where the owner of a department store, hotel or office building, having to have steam plant anyway for heating and other purposes, can put in an extra engine, run it as a reducing valve between his high-pressure boilers and his heating or low-pressure service and make what current he needs more cheaply than a central station can make and deliver it to him at a profit. In fact, there are records available where such a thing has been done. In fact, again, there is something very exceptional about a case where an industrial establishment or building of size worth considering cannot be run on less money, when heating is as much of a factor as it ordinarily is in any but southern latitudes, if it makes its own electric current than if it buys it.

Try the shoe upon the other foot. There are people whose interests are with the isolated plant rather than with the central station: manufacturers and salesmen of engines and generators and power-plant supplies, consulting engineers who have advised against central-station service when it appeared to them that their clients could make current cheaper, engineers of public plants shut down by the usurpation of the central station, high-class operative engineers of the professional type who are in charge of large installations and know what it costs to run them. Suppose that some of these wanted a meeting held under the auspices of one of the great national professional societies to present their side of the case.

Could they get it?

Having got it, would there be any kind of a howl if they monopolized the meeting with the perverted statements of the most unreasoning of their adherents; watch and gavel in hand, stood over anybody who approached the subject from the other side; if, after all their ammunition had been spent, many of the audience had left and all were ready to go they threw the discussion open at a minute a head, and then published the performance as the "proceedings" of a national scientific institution?

We know of nothing which would be more interesting and profitable than a dignified professional discussion of "The

Cost of Industrial Power," backed by statements of initial cost and of actual accomplishment. There is plenty of information of this kind to be had. There are plenty of men who are qualified to discuss it intelligently, even the accountants' side of it. It ought to be discussed without prejudice and with no more warmth than the interest warrants, from a purely engineering point of view; and when one class of men claim that they can make a kilowatt-hour for a cent and another class claim that it is really costing them fifteen but that they do not know it, there ought to be enough brains in a free-for-all meeting to find out whether the difference is one of fact or of bookkeeping.

We should like to see such a meeting arranged, in the interest of the truth; not organized for and by those whose aim is to boost the popular conception (and especially the Public Service Commission conception) of the cost of power nor of him whose interest lies in reducing that conception, but for the manufacturer, the engineer, the power user who wants to get at the facts in the matter.

Pending such a meeting the columns of POWER are open to any who have real information upon the subject.

Interest and Sinking Fund

If the life of an installation of power plant is assumed to be twenty years, then it would appear at the first glance as though there must be charged against operation one-twentieth, or five per cent., of its cost each year, as it uses up that amount of plant each year on the average, as well as coal and other supplies. But if five per cent. of a sum be set aside each year and be put at compound interest at six per cent. it will amount to 184 per cent. of the original sum at the end of the twenty years. It is necessary to set aside only 2.7 per cent. in order that the full sum may accumulate and accrue and be ready to replace the plant at the end of its assumed lifetime.

At the recent New York meeting of the American Institute of Electrical Engineers, held to discuss power costs, one of the central-station solicitors maintained that it was not right to so reduce the sinking-fund charge because inquiry upon his part had revealed the fact that nobody invested the money thus charged annually to the plant at compound interest.

Well, what do they do with it? They don't put it in a safety-deposit vault, or soak it away in a stocking. They keep turning it over in their business and make it earn twenty or thirty per cent. If the steam plant were credited with that rate of interest its sinking-fund charge would be low indeed. But that would not be fair, for the owner could borrow at six per cent. for his commercial or manufacturing operations.

And in the face of this refusal to credit the plant with ordinary interest upon money which they insist it shall earn and set aside for its own replacement, the central-station men want the man who is considering the installation of an isolated plant as against buying current to virtually charge the plant with interest at the rate of profit in his most profitable department, upon the plea that he had better use the money there than to put it into power plant if the plant cannot beat the most profitable department as a money maker; which would be true if the department were capable of such extension as to absorb all the capital and the owner were "broke."

Inertia

Inertia is defined as the inability of matter to set itself in motion, or of a moving body to change the rate or direction of its motion. A broader application of this definition covers those peculiar attributes of the human mind which induce many to bury themselves in a rut or a ditch so deep that their horizon is limited by the blank wall in front of them. When study for improvement is suggested, it is often met with the abject confession, "I didn't have much schooling an' those things are beyond me." No man's education ceases at the school door unless he wilfully shuts his eyes and his ears when he tosses his school books aside. In fact, the largest part of anyone's education comes outside of books. Some of the most ignorant men have had all of the advantages afforded by schools and colleges and have failed to profit thereby, while some of the best educated men in the world have been entirely self-taught. A man's education commences the instant he begins to see and only stops when he ceases to see. In this he is governed by his own inertia or his lack of it—the inertia that prevents a man from advancing himself, the initiative which prompts a man to seek out the explanation of those phenomena which daily life presents.

At the close of his paper on the "Art of Cutting Metals," presented by F. W. Taylor, when retiring from the presidency of the American Society of Mechanical Engineers, are found the following words:

"And let me point out that the most important lessons taught by these experiments, particularly to the younger men, are that several men when heartily cooperating, even if of only everyday caliber, can accomplish what would be next to impossible for any one man even of exceptional ability.

"Expensive experiments can be successfully carried on by men without money, and the most difficult mathematical problems can be solved by very ordinary mathematicians; provided only they are willing to pay the price in time, patience and hard work. The old adage is again made good that 'All things come to him who waits,' if he only works hard enough in the mean time."

The same amount of time and energy that the average man devotes to memorizing the standing of the different baseball clubs and the players would, devoted to a subject connected with his occupation, render him an authority on that line.

The corrosion of condenser tubes is one of the serious items of expense and trouble about a power station. In one of the large New York stations the surface condensers have to be entirely retubed after a service of not more than three years. It is pleasing to learn, therefore, that the Institute of Metals, of Great Britain, has appointed a committee to investigate the subject of corrosion, and that the first subject which they will take up is that of condenser tubes. Sir Gerard Muntz, the president of the Institute, is naturally much interested in the subject, and G. D. Bengough, of the metallurgical department of Liverpool University, is in charge of the scientific work.

That a chain is no stronger than its weakest link is an old and familiar maxim. The same reasoning applies to many other things besides chains. One weak spot in the insulation of an armature, for example, can cause the destruction of an otherwise sound generator. A set screw of insufficient size or "bite" can wreck the finest steam engine ever built, by allowing the key to back out of the connecting-rod strap. A cheap, unreliable ignition system will "kill" a $100,000 gas engine just as effectually as the use of rotten material in the crank shaft, though equal mechanical damage would not be caused.

Having awakened to the advantages of electric ignition ten years late, our British cousins are about to make the parallel discovery that the hit-and-miss method does not embody all of the cardinal virtues of regulation for gas engines of moderate output.

But those same English cousins have keenness of vision when it comes to discerning the buttered side of a slice of bread. They don't figure crank pins and such with a margin of $2\frac{9}{16}$ per cent.

The National Assembly of Panama has recently voted $100,000 in aid of the proposed world's fair to be held in Panama City in 1915. The more, the merrier, providing it does not interfere with Louisville or San Francisco.

If everybody had the moral courage to tell the whole truth always, we'd all know "where we're at" and everybody would be really more contented.

Notes on the Cost of Industrial Power

Two papers and the discussion of them at a joint meeting of the American Society of Mechanical Engineers and the American Institute of Electrical Engineers. The original papers deal with methods to be used in arriving at the cost of power in isolated plants as viewed from the central station standpoint.

On Friday evening, March 10, the American Society of Mechanical Engineers and the American Institute of Electrical Engineers held a joint meeting at which were presented several papers upon the cost of producing power.

John C. Parker, of the Rochester Railway and Lighting Company, delivered a paper entitled "Comments on Fixed Costs in Industrial Power Plants." Beginning with the initial investment he pointed out the necessity of including the cost of real estate, building, equipment and all labor involved in connection with the erection of a plant, depreciation being charged against the labor and supervision items as well as the equipment itself. It was shown that boilers depreciate more rapidly than engines which, in turn, depreciate faster than buildings and so on; hence, a separate rate should be applied to each, the basis for calculation being that the life of any plant is the length of time for which it can be run economically.

Regarding insurance, if the installation of a plant increases the fire hazard on the property as a whole, the net increase of insurance should be charged against the plant which occasioned the increase. Furthermore, to the ordinary fire insurance must be added accident and liability insurance. This expense is existent whether such insurance is actually carried, or not, as a sum equal to the insurance premiums must be laid aside to provide for such contingencies for which the insurance is carried.

An "obsolescence" charge, meaning the supersession of the apparatus initially installed by a more efficient piece of apparatus which may be developed before the initial apparatus has reached the scrapping stage, was not considered important, even though the supersession take place under stress of competition. For this would not be undertaken unless the new apparatus could save enough to justify the expense, in which case the saving must take care of that much of the new investment as is not already covered by the sinking fund.

Mr. Parker laid considerable stress upon what he termed the "marginal principle." This, briefly stated, is to the effect that if any part of a business requires time, material or investment which could have been utilized in any other part of the business, the cost thereof should be taken as the amount such time, material or investment would have earned if applied to the most profitable part of the business which is capable of extension. To illustrate this he cited the case of a department store in which, for every $1000 invested in the china department, a yearly profit of only $100 is made, whereas each $1000 invested in the clothing department yields a yearly profit of $300. Hence, according to the marginal principle, the $1000 invested in china actually showed a loss of $200 per annum which should be charged against the china department. If, then, an enterprise is making a net profit of 10 per cent. per annum on the average—and not less and probably more than this on certain details of the business—there

TABLE I.

Item.	Cost.	Life, Yrs.	Amortization. Rate, Per Ct.	Amortization. Amt.
Engines	$4,195	20	2.67	$112.00
Boilers, stokers and breeching	6,200	20	2.67	165.54
Stack	1,000	30	1.23	12.30
Generators and switchboard	4,700	25	1.78	83.66
Boiler auxiliaries	620	12	5.82	36.08
Piping	2,150	20	2.67	57.40
Foundations	300	20	2.67	8.01
Coal hoist	600	10	7.45	44.70
Aggregate	$19,765			$519.70
Mean			2.63	
Freight and rigging	500		2.63	13.15
Total	$20,265			$532.85

	Per Cent.
Marginal interest	6.00
Amortization	2.63
Taxes and insurance	3.00
Fair profit ratio	11.50
Aggregate	23.13

BALANCE SHEET.

PURCHASED POWER.

Fuel

For heating, based on 10 pounds evaporation

Day coal	280 tons
Night coal	231 tons
Banking coal	20 tons
Total	531 tons
Cost @ $2.60 per ton	$1,380

Ashes

Ash, 12 per cent. Total ashes, 64 tons; removal cost @ 25 cents per ton 16

Labor

1 fireman 52 weeks @ $15	$780	
1 fireman 20 weeks @ $15	300	
		$1,080

Supplies and Repairs

$0.794 per horsepower per year 200 horsepower installed 160

Water

Assume 10 per cent. loss in system cost @ $0.012 per 1000 pounds 12

Electric Service

Present maximum demand ..... 107 kilowatts
Estimated future maximum demand ..... 140 kilowatts
The maximum and kilowatt-hours used each month for the past year have been increased by the ratio of 140 to 107

Month.	Kilowatt-Hours, 107–140.	With Discount.
June	15,980	$493
July	14,850	365
August	15,270	399
September	12,540	401
October	20,820	535
November	27,450	610
December	32,800	655
January	27,420	605
February	25,230	581
March	20,720	541
April	20,700	540
May	19,530	534
	253,310	$6,259

Total	$6,259

Elevator Service

Present installation, estimated cost ... 415

Fixed Charges

Estimated value of heating plant, $3,200.
Fixed charges at 25 per cent 800

Manager's Time

And clerical expense	25
Credit to balance	2,816
Total	$12,963

ISOLATED PLANT.

Fuel

253,000 kilowatt-hours @ 6.5 pounds coal per kilowatt-hour ..... 823 tons
Banking coal ..... 58 tons
Total ..... 881 tons
Cost @ $2.60 per ton $2,290

Ashes

Ash, 12 per cent. Total ashes 100 tons.
Removal cost @ 25 cents per ton 25

Labor

1 day engineer @	$21	per week
1 night engineer	17.50	per week
1 fireman @	15	per week
Total	$53.50	per week

All labor on for 52 weeks
Total cost per year $2,780

Supplies and Repairs

Cost per year per boiler-horsepower installed $1.22. Cost of 300 horsepower. 366

Water

10 per cent. loss during winter and exhaust wasted during summer
Cost per year 60

Emergency Service

At 250,000 kilowatt-hours per year, average per day is 800, average per hour 33.

Assume 4 days shutdown per month, at one-third load or 11 kilowatts for 100 hours, a total of 1100 kilowatt-hours. Assume maximum demand at twice the average.

Hours use $\frac{1100}{22 \times 26} = 1.9$

Rate 7.1 cents.
Cost per month $78
Cost per year 936

Elevator service

Present installation, estimated cost ... 415

Fixed Charges

Estimated cost of plant $19,200
Fixed charges @ 23.13 per cent 4,441

Manager's Time

One-half hour daily of 6-hour day @ $12,000 per year 1,000
Clerical expense, 1 hour daily, 300 days per year @ 50 cents 150

Rental Value of Space

500 square feet @ $1 per square foot ... 500

$12,963

is at least a 10 per cent. loss per annum on the investment of money in a power plant, if the money earns only the fixed items of taxes, insurance, interest, depreciation and supervision, and the amount lost is just what could have been gained by the investment of such a sum in the most profitable part of the business.

As an illustration of the methods laid down, Mr. Parker appended figures intended to show the cost of supplying a large mercantile establishment with power from an isolated plant as compared with central-station service. The plant selected was of 150 kilowatts capacity and the fixed charges were assumed at the rates given in Table 1.

The second paper of the evening was by Aldis E. Hibner, of the Toronto Electric Light Company, and was in part as follows:

There are in general three factors involved in every industrial-power problem: the investment charges, operating charges and the cost of heating or the use of low-pressure steam. The investment charges are understood to cover the interest, amortization, insurance, taxes and profit on the capital invested in the plant. The operating charges include coal, labor, repairs and supplies. The cost of heating is the investment and operating charges of the boiler plant necessary for heating the building and supplying steam for manufacturing processes.

TABLE 2.

HEATING PLANT INVESTMENT.

Boiler, piping and auxiliaries (A)	$1,500.00	
Building and stack (B)	2,500.00	
Total investment	$4,000.00	
FIXED COST.		
Interest 6 per cent. on $4000	$240.00	
Insurance and taxes, 2 per cent. on $4000	80.00	
Amortization on A, 4½ per cent., 15 year life	67.50	
Amortization on B, ½ per cent., 50 year life	12.50	
		$400.00
OPERATING COST.		
Coal, 475 tons @ $3.00	$1425.00	
Fireman @ $15.00 per week	780.00	
Supplies and repairs	100.00	
		2305.00
Total cost		$2705.00

Assume as a typical example of the conditions ordinarily found, the Blank Shoe Company, which has outgrown its present quarters and has decided to build a new factory having a floor area of 60,000 square feet and a cubical content of 750,000 cubic feet.

One of the first things which must be determined before starting construction is whether power shall be purchased or supplied from a private plant. The first step in the solution of this problem is to determine the cost of heating the building. A heating plant is necessary in any case, as the conditions of manufacture are such that the temperature of the building must be kept above fifty degrees during the winter months.

The coal consumption is based on an evaporation of seven pounds of water per pound of coal, one change of air per hour in the factory and the supplying of radiation losses. During zero weather 90 boiler horsepower will be required. Having determined the size of boiler plant necessary the next step is to take up the cost of heating. Table 2 gives the investment necessary, together with the fixed and operating costs of the plant.

Replacement of the plant has been provided for by a sinking fund drawing 5 per cent. interest compounded semi-annually, based on a life of the various parts of the plant as given in the table. The time of the fireman has been figured for the entire year, as steam at high pressure is required the entire year for industrial purposes. It is of interest to note that the cost of coal represents only a little over 50 per cent. of the total cost of heating, and that a variation of 25 per cent. in the amount of coal burned causes only 13 per cent. variation in the total cost.

Having determined the expense which is absolutely necessary in connection with the power requirements, the question asked is whether it is advisable to go a step further and make the additional investment necessary for generating power, or whether it shall be purchased from a power company. The answer, obviously, depends upon the additional cost of producing this power and the rate at which power can be purchased. Having determined the former, the rate at which power can be purchased to advantage is fixed.

The concern under consideration has a maximum demand for 100 kilowatts of power. The average load is 80 kilowatts, giving an 80 per cent. ten-hour load factor. The engine is of the Corliss noncondensing type, requiring 30 pounds of steam per indicated horsepower-hour. The boiler evaporation is taken at seven pounds of water per pound of coal, giving a coal consumption of 4.3 pounds per indicated horsepower-hour. The efficiency from steam cylinder to switchboard is 78 per cent., giving a coal consumption of 7.39 pounds per kilowatt-hour or 5.51 pounds per horsepower-hour at the switchboard. The factory runs 300 days per year.

Table 3 gives the investment cost, fixed cost and operating cost of the plant, allowance being made for the cost of heating, as calculated.

Among the items of fixed cost will be found one covering a profit on the additional investment required for a power plant. It is clear that a concern is not justified in investing in a power plant unless the capital so invested returns the same profit as if invested in the most profitable part of the business still capable of extension. When the added risk is taken into consideration, this could safely be raised to 10 or 15 per cent. It is evident from these results that if power can be purchased for 2.3 cents per kilowatt-hour there is no advantage in installing a steam-power plant.

TABLE 3.

COMPLETE POWER PLANT INVESTMENT.

Capacity, 100 kilowatts.

Engine, generator, switchboard, wiring (A)	$5,500.00	
Boilers, steam piping, auxiliaries (B)	5,000.00	
Building, foundations, stack (C)	5,000.00	
		$15,500.00
Steam-heating plant		4,000.00
Additional for power		$11,500.00
FIXED COST OF POWER PLANT.		
Interest, 6 per cent. on $15,500	$930.00	
Profit, 5 per cent. on $11,500	575.00	
Insurance and taxes, 2 per cent. on $15,500	310.00	
Amortization on (A), 3 per cent. (20-year life)	165.00	
Amortization on (B), 4½ per cent. (15-year life)	225.00	
Amortization on (C), ½ per cent. (50-year life)	25.00	
		$2,230.00
Fixed cost on heating plant		400.00
Additional for power		$1,830.00
OPERATING COST OF POWER PLANT. 240,000 kilowatt-hours.		
Coal @ 7.39 pounds, 887 tons @ $3.00	$2,661.00	
Banking, 181 tons @ $3.00	543.00	
Night heating, 202 tons @ $3.00	606.00	
Engineer @ $18.00 per week	936.00	
Fireman @ $15.00 per week	780.00	
Water	100.00	
Oil, waste, supplies	150.00	
Repairs	200.00	
		$5,976.00
Operating cost of heating plant		2,305.00
Additional for power		$3,671.00
Total additional for power		5,501.00
Cost per kilowatt-hour		0.0229
Cost per horsepower year		51.40

At the present time, however, an engineer would scarcely make any decision without investigating the cost of producing power by means of a gas-producer plant. The most active competitor of the steam engine for power production is the gas-producer plant. This type of plant, which has developed since 1900, has shown remarkable economy of coal consumption when handled by experienced operators. The United States Geological Survey report on gas-producer plant shows that for an average of a great many tests the noncondensing steam plant requires 2.7 times as much coal per unit as the producer plant. Their results give a thermal efficiency at the switchboard of 4.86 per cent. for the steam plant and 13.5 per cent. for the producer plant. The maximum attainable efficiency is probably 10.3 per cent. for the steam plant and 21.5 per cent. for the gas producer under present conditions. In view of this known economy a great many producer plants have been installed in the last few years.

For the factory under consideration the conditions will require the installation of a 175-horsepower engine and producer, and in addition a heating plant for heating the building. As this heating plant is required in any event, the cost of heating is eliminated as a comparative fac-

tor in the problem. The investment, fixed costs and operating costs of this plant are given in Table 4. The cost of the plant is somewhat higher than the corresponding steam plant. The life of the plant is also shorter. This gives a higher fixed cost than for the steam plant.

TABLE 4.

GAS PRODUCER PLANT.

INVESTMENT.		
Engine and producer (A)	$11,900.00	
Generator, switchboard, wiring (B)	2,500.00	
Building (C)	2,500.00	
	$16,900.00	
FIXED COST.		
Interest, 6 per cent. on $16,900	$1,014.00	
Profit, 5 per cent. on $16,900	845.00	
Insurance and taxes, 2 per cent. on $16,900	338.00	
Amortization on A, 15-year life, 4½ per cent.	535.00	
Amortization on B, 20-year life, 3 per cent	75.00	
Amortization on C, 50-year life, ½ per cent.	12.50	$2,819.50
OPERATING COST.		
240,000 kilowatt-hours.		
Coal, 3 pounds per kilowatt-hour @ $4.00 per ton, 360 tons	$1,440.00	
Engineer @ $18.00 per week	936.00	
Oil and waste	125.00	
Repairs	300.00	
Water	133.00	
Emergency service	300.00	$3,234.00
Total		$6,053.50
Cost per kilowatt-hour		0.025
Cost per horsepower-year		56.20

The operating costs of the producer plant are only about one-half that of the steam plant. This, however, is counterbalanced by the cost of heating. The final result gives a slightly higher cost for the gas-producer plant. The ratio of the fixed cost to operating cost in the two cases, however, produces a very marked effect where the load factor is poor. The only items affected by the output of the plant are coal and water. These represent only about 27 per cent. of the total cost, as against 50 per cent. with the steam plant, the result being a very much higher cost for the gas producer at low load factors. The poor fuel economy on light loads would further exaggerate this effect.

DISCUSSION

Mr. Moses: I think Mr. Parker's paper is typical of the central-station point of view, in that it exaggerates each item of the cost and the result is a great exaggeration. He says that since the installation of a plant costing $10,000 to $20,000 will constitute a physical improvement to the property, it is obvious that the taxes will be increased. I have installed a number of plants in this city and do not know of a single case where the taxes have been increased. Furthermore, I do not know of any cases where the taxes have been decreased, owing to a plant having been discontinued.

On the subject of insurance, Mr. Parker allows a charge of 3 per cent. In the modern fireproof building the insurance on the contents is about one-quarter of one per cent. In addition to this there is the liability and accident insurance. This, in New York State, under the new law is about 3 per cent. of the cost of labor, and of the labor in the boiler and engine rooms about one-half is chargeable to the heating. In a plant costing $20,000, the labor will be about $5000 per annum; hence, this charge would be about $75 per year, which is about three-quarters of one per cent. upon the investment.

Considering the cost of the equipment in the typical isolated plant selected by Mr. Parker, the cost of a 100-kilowatt engine and a 50-kilowatt engine is given as $4195. We recently purchased two 100-kilowatt engines for $3000.

Mr. Bolton: I wish to controvert the statements of the previous speaker in so far as they refer to conditions in this city. The insurance on hazardous labor has now risen in this State until it amounts to nearly 6 per cent. Mr. Parker has amortized his depreciation at a rate of compound interest which we are not able to get in this city, namely, 6 per cent. Referring to the table showing the rate of amortization, I would say that, capitalized at 3 per cent., which is the rate obtainable in most savings banks, the average would be more like 4.5 per cent. on the total; hence the figure given in Mr. Parker's table should be increased by about 2 per cent.

The use of exhaust steam as a byproduct depends upon climatic conditions; the nearer the plant is to the North Pole, the more efficient the use of the exhaust steam; and the nearer to the Equator, the less efficient its use becomes. The following statistics, showing the percentage of live steam used based upon the total steam supplied, are taken from the records of a large steam company in this city: October, 3.2 per cent.; November, 7.2 per cent.; December, 15.5 per cent.; January, 25.7 per cent.; February, 22.6 per cent.; March, 20.6 per cent.; April, 5.2 per cent. The corresponding figures for a large office building situated only a few blocks from the other plant, were as follows: October, 13.4 per cent.; November, 12.9 per cent.; December, 14.8 per cent.; January, 15 per cent.; February, 13.9 per cent.; March, 16.1 per cent.; April, 13.73 per cent. If anyone can make these fit together, I should be glad to know it

Mr. Williams (New York Edison Company): I am compelled to take issue with Mr. Parker and Mr. Hibner; they have not placed the cost of current, at least under conditions existing in such a city as New York, at anywhere near its true value. In Mr. Hibner's paper the amount allowed for heating the building with an average steam-heating load of 62 horsepower is altogether too high; $2000 should cover the investment instead of $4000, and upon this basis the annual fixed cost upon the investment would be $300 and not $600. As to coal, for heating alone the cost appears overstated. Four hundred tons, for an average of 62 boiler horsepower for the heating season, would be sufficient, which, at $3 per ton, would cost $1200. In the matter of labor, a fireman's wages for a full year have been charged. Assuming that one would be sufficient, the wages chargeable to heating for thirty instead of fifty-two weeks would be $450. Making these changes, the yearly cost of heating the building would be about $2000 instead of $2705. I would summarize the fixed charges at 15 per cent., and, making this allowance, the final result becomes 5.5 cents per kilowatt-hour instead of 2.29 cents.

Referring to gas-producer plants, they are hardly more reliable in their operation and hardly longer in life than an automobile engine. Therefore, I would change the ratio of depreciation on the total investment to 20 per cent.

Mr. Parker estimates 2.63 per cent. as the annual depreciation, but I do not know of any case where annual depreciation is actually put aside in a fund upon which interest is accumulated from year to year. Therefore, I would change the general depreciation rate to 7.5 per cent. Two causes for depreciation have been given—obsolescence and physical life; however, there is a third, and that is, the moment that a competing service becomes available at a cost not exceeding the cost of operating the private plant, then the depreciation of that plant has become 100 per cent., and so long as its operation is continued, it must be apparent that operation is continued at a loss to the operator.

Some years ago Mr. Parsons presented a paper in which he gave the average number of pounds of coal consumed per kilowatt-hour in a number of plants. I believe there were three apartment houses, three hotels and three clubs, representing in these three classes the most difficult service with which a central station in a large city must compete. I have never seen the accuracy of Mr. Parsons' figures questioned, but I have seen them confirmed in many ways. They show as high as 25 pounds of coal per kilowatt-hour generated, including the coal required for heating. The average was 17.3 pounds, and the average of all, divided by the kilowatt-hours required, was 15.5 pounds of coal per kilowatt-hour. Contrasted with this it is customary to base preliminary estimates on from 6 to 7 pounds of coal per kilowatt-hour.

Mr. Kemble: In Mr. Hibner's paper the item of profit is taken at 5 per cent. I do not think any manufacturer will go into business on the basis of a 5 per cent. profit, with the anxiety and worry and chance of failure, when that profit can be obtained by the purchase of any ordinary good bond on the market. I

called up a half dozen manufacturers in Brooklyn and asked them what turnover they would consider it necessary to have on $15,000. The lowest man of the six gave a turnover of 15 per cent., on the basis of 5 per cent. for the use of the money, thus giving a net profit of 10 per cent., twice the amount given in the paper. The highest man of the lot gave a turnover of 30 per cent., stating that they turned over their money on an average of ten times a year, with a profit of 3 per cent. each time. Between these two extremes it would be safe to take 15 per cent. as a fair profit.

As to the amount of coal, my experience in plants of this size has shown that about ten pounds of coal per kilowatt-hour is a conservative figure. If that is taken into consideration, together with the increased profit, it will bring the cost per kilowatt-hour to 2.84 cents. If allowance is made for part of the manager's time, this, together with either of the other items, will bring the cost of power, based on Mr. Hibner's figures, to over three cents per kilowatt-hour. Any large public-service corporation would be very glad to supply power to such a plant for three cents per kilowatt-hour on a term contract.

Mr. Ripley: I would like to have it go on record that the Commonwealth Edison Company, of Chicago, to my own certain knowledge, owns and operates three isolated plants in the basements of buildings. If these industrial-plant owners need any further encouragement, as far as depending upon these certain engines is concerned, I will say that the Commonwealth Edison Company depends upon the Ideal engine and upon the Corliss engine, as well as high-speed engines, and I cannot see but that the owners of industrial plants can likewise depend on similar apparatus designed by the same people.

Mr. Fowler: When I received the notice of this meeting tonight it struck me that we were coming here to discuss a problem that was about as easily solved as it would be to discuss the size of a piece of chalk the length of a piece of string. It is a very easy thing to sit down and tell what a plant should do, but it is almost impossible to sit down in advance and tell what it actually will do. It is not difficult to go into a plant and make an analysis of what they are doing and get the figures, but to sit down in cold blood in an office and figure out what it is doing, with all the variables that must be taken into account, is almost an absolute impossibility.

Mr. Parker: I want to clear the ground ethically. Mr. Moses refers to the paper I offered as being characterized by central-station animus. I tried to keep it from that as much as possible. It is manifest that a central-station man would be decidedly idiotic if he attempted to exaggerate the claims at all in favor of himself. I answer that statement by the obvious statement that the only thing a central-station man can offer to do is to make his claims as reasonable as possible. Mr. Moses misunderstood the statement of the insurance charge. Insurance is not claimed to be 3 per cent.—taxes and insurance are said to be 3 per cent., and that would cover casualty insurance on both patrons and employees.

The rental value of the space is, I believe, absolutely right. The proprietor of the store acknowledged the figures used in the table as being right. The basement of a department store handles five-, ten-, twenty-five and thirty-cent articles, which sell with a tremendous margin of profit, and in tremendous volume. That is good rental space in a department store. The figures are given as representative of what obtained in the specific plant in question. I do not mean that the rental value for power-plant sites given in this table would apply to every type of building necessarily. The actual cost figures given are unquestionably large, but these prices were actually paid by responsible manufacturers for the plant delivered in place ready to operate. The figures for the engines cover the holding-down bolts, putting the engine together, limbering up and getting ready to turn over, and as to the latitude of the figures elsewhere, the point is made that synthetic plant costs are different from form quotations, which a man will make good on. Form quotations are 50 to 75 per cent. higher than the synthetical plant cost.

I cannot too heartily indorse what has been said in regard to the pernicious practice of retaining engineering service in connection with industrial-power work. Having a man work on salary for a public-service enterprise, or having him work on commission, is rather objectionable, because I know, personally, that with the best motives in the world a man finds it very hard not to be biased by his own personal interest. I believe that the salvation of such a situation will come in this way—that the industrial engineer employed by a public-utility company will recognize that the best interests of his company consist not in taking all the business there is in sight, but in taking only that business which he, as an independent consulting engineer, would recommend a client to take. The central-station engineer doing that will get away from the prejudicial results of his personal bias. The man in private practice should not work on commission; he should work for a retainer or for a fixed sum, and that sum should be amply large. I think that most of the industrial-engineering work today is being done for utterly miserable fees, and the result is that the pressure is very great on a man to sacrifice his highest ethical standard or to allow his judgment to be governed by his personal interest in the way of trying to bolster up his commissions.

The written discussion, which was not given at the meeting, will follow in a later issue.

Blowoff Tank Accident

The bottom of a cast-steel blowoff tank was blown out, on February 21, at the Pittsfield Y. M. C. A. building and the engineer was badly scalded. The plant consists of two 54-inch boilers, two turbines and auxiliaries and apparatus for filtering the swimming-pool water and lighting and heating the building. One boiler was being blown down under 125 pounds pressure. The 2-inch blowoff pipes from the boilers united in the 2½-inch line which led to a 36x36-inch tank. The 2½-inch sewer outlet was sealed with water and there was a 2-inch vent to atmosphere as usual. The flat bottom of the tank apparently dropped out under pressure and the tank lifted, bending a steel I-beam above it and breaking several 3-inch water pipes. It is supposed that the bottom of the tank was filled with scale and so prevented the sewer outlet from working.

Coal Land Frauds

It is reported in the daily press that the Government investigation into alleged Alaskan coal-land frauds involving approximatelly 48,000 acres of land, valued at more than $50,000,000, has resulted in the issuance on March 6 of an indictment by the Federal grand jury at Detroit, charging seven individuals with conspiracy against the United States.

The contention of the Government is that the defendants conspired to induce between 200 and 300 individuals to become stockholders in the Michigan-Alaska Company by making fraudulent and fictitious locations of certain Alaska coal lands," thereby violating the land-entry laws of 1910, which made it illegal for more than four persons to form a company for locating Alaska coal lands and taking out patents on more than 640 acres. It is alleged that several stockholders or coal-land claimants were led to believe that they were locating the lands for their exclusive use, "but in truth and in fact for the use and benefit of the seven defendants and the Michigan-Alaska Development Company."

The Michigan-Alaska Development Company was organized under the laws of Arizona. W. W. McAlpine is the president. The coal lands involved are situated at Juneau, Alaska, and several contiguous tracts in the vicinity of Homer, upon the westerly end of Kenai peninsula, bordering upon Cook inlet. The claims are said to have been located by about two hundred Detroit and Michigan residents and a hundred other claimants from New York, Chicago, San Francisco, Seattle and other points.

Donkey Engine Boiler Explodes and Kills Seven

On March 4, the boiler of a donkey engine in the logging yard at the river mill of the Portland Railway, Light and Power Company near Estacada, Ore., exploded and caused the instant death of five men, the injury and subsequent death of two others and the serious injury of still another. The boiler rose 500 feet in the air and fell to the ground a quarter of a mile away. For several days, it is said, the safety valve on the boiler had not been working satisfactorily and experiments had been carried on with a number of improvised devices. On the very morning of the explosion one of the contractors had started for Portland with the express intention of providing a new valve, but he had only gone a few miles when reports of the explosion caused him to retrace his steps.

Wisconsin Engine Company Makes Extensive Additions

The Wisconsin Engine Company, of Corliss, Wis., which is about twenty miles from Milwaukee, has just made a considerable addition to its equipment and working capital. Hitherto the company has been controlled by strong Pittsburg interests, but on account of its location it became desirable to bring Milwaukee capital into the company, and two of the new directorate are prominent business men of the latter city. E. T. Adams has been made president of the company.

Heretofore the principal business of the Wisconsin Engine Company has been the manufacture of Wisconsin Corliss engines. It is the purpose of the new organization to foster and to build up the existing Corliss-engine business, but the addition of new capital and new equipment is chiefly for the purpose of enabling the company to enter extensively into new lines of manufacture. Chief of these will be the Adams gas engines, which will be manufactured in sizes from 200 to 3000 horsepower in a single unit. It is stated that the company has already secured orders for upward of 10,000 horsepower of the Adams engines, and increased shop facilities and new equipments are now being installed to permit the rapid and economical production of this additional line of manufacture.

E. T. Adams, the new president of the company, has been identified with the manufacture of heavy machinery for many years, dating back to the early days of the Edward P. Ellis Company, of Milwaukee, where, under Mr. Reynolds, he was connected with the design and installation of most of the important power and pumping installations in the country. Mr. Adams was a pioneer in the heavy gas-engine business in the United States, being identified with the first large gas engine put out by the Westinghouse company and later the manager and chief engineer of the gas- and mill-engine department of the Allis-Chalmers Company. It is probable that considerably over half of the large gas engines now in operation in this country are of Mr. Adams' design, including the Allis-Chalmers engines in the plant of the Steel Corporation at Gary, Ind.

Second Monthly Meeting of Engineers' Institute

The second regular monthly meeting of the proposed Institute of Operating Engineers was held at the Engineering Societies building, New York City, on March 9. About 150 members and friends of the temporary organization were present.

Prof. W. D. Ennis, of the Brooklyn Polytechnic Institute, delivered a paper entitled "The Commercial Aspect of the Work of the Operating Engineer." An abstract of this paper will be published in a following issue, together with an abstract of the discussion which was offered by Willis Lawrence.

Cast Iron Elbow Bursts

On February 27, a cast-iron elbow in the blowoff pipe of a 135-horsepower horizontal tubular boiler in the plant of the La Porte Electric Company burst while the boiler was being fired up. A pressure of 40 pounds was on the boiler at the time. The boiler was shaken in the setting and the brickwork considerably damaged. Had the accident occurred after the boiler had been cut in the battery with the six other boilers at 125 pounds, there is not much doubt that the accident would have been more serious. The boiler had been washed out and inspected on February 16 and had not been used since that time. This is only one more reason why cast-iron fittings should not be used.

On February 17, Governor Dix sent a special message to the legislature recommending that a resolution be passed urging upon Congress careful consideration of two bills now before that body relating to the use of hydraulic power of the Niagara river and confirming a legislative grant for hydraulic development of the St. Lawrence river by the Long Sault Development Company. These measures are known respectively as the Alexander and Oliver bills.

A bill has been introduced in the Ohio State legislature providing for the formation of a State department of boiler inspection. A chief inspector at $2400 and six deputies at $1800 per annum are authorized. This department is to have supervision of all stationary boilers except those used for heating plants and very small boilers. An inspection fee of $5 is to be charged.

PERSONAL

C. W. Van Blarcom, New York representative of Neemes Brothers, of Troy, for the past fifteen years, died suddenly on March 7. Mr. Van Blarcom was 40 years of age and leaves a widow.

Moses Nelson Baker, editor of *Engineering News*, was the speaker of the evening at the charter-day exercises of the fifteenth anniversary of the Thomas S. Clarkson Memorial School of Technology, held on March 17. The topic chosen by Mr. Baker was "The Engineer and Social Service."

George Q. Palmer, formerly vice-president, has been made president of the Alberger Condenser Company and the Alberger Pump Company. Mr. Palmer is succeeded as vice-president in the Alberger Condenser Company by D. H. Chester, and in the Alberger Pump Company by W. S. Doran.

On March 18, John W. Lane, formerly an engineer of Providence and for some time editor of the *National Engineer*, the official organ of the National Association of Stationary Engineers, was tendered a reception by Rhode Island No. 1. He was greeted by a large number of friends from Rhode Island and Massachusetts.

NEW PUBLICATIONS

A bulletin describing the Moore patent automatic fuel-oil regulating system and entitled "Unnecessary Losses in Firing Fuel Oil and an Automatic System for Eliminating Them," is being issued by Charles C. Moore & Co. It can be obtained upon request from the offices of the company at San Francisco, Los Angeles, Seattle, Portland and Salt Lake City.

The system controls the supply of oil to all burners, the supply of the atomizing agent to all burners, and the supply of air for combustion, for any number of boilers, all from a central point. The results claimed are: Increased boiler-plant efficiency, the practical prevention of smoke, and the decrease in the maintenance cost of boiler equipment, due to a more uniform manner of firing. Such a system was first installed at the Redondo plant of the Pacific Light and Power Company in 1907. Here the regulating system is used to control the entire plant of 18 boilers of 600 horsepower each, and the increased economy, due to the uniform rate of firing, is very evident.

QUALITATIVE CHEMICAL ANALYSIS. By J. I. D. Hinds. Published by the Chemical Publishing Company, Easton, Penn., 1910. Cloth; 285 pages, 5½x9 inches. Price, $2.

A textbook treating the subject of qualitative analysis from the standpoint of ions, solubilities and mass action. By this method it is hoped that the student will be better prepared to take up the study of physical chemistry. The classification of the kations is similar to that used in other textbooks, but a systematic method of separating and identifying the anions is given, which should prove helpful to the beginner. There is a complete list of the reagents and the solutions, together with the methods of preparing them to a given concentration. Among the useful tables is one giving the solubility in water of most of the substances ordinarily met with as precipitates in the course of analysis.

BOOKS RECEIVED

STEAM TURBINES. By Rankin Kennedy. The Macmillan Company, New York. Cloth; 101 pages, 5½x8½ inches; 62 illustrations. Indexed.

MOTION STUDY. By Frank B. Gilbreth. D. Van Nostrand Company, New York. Cloth; 116 pages, 5x7¾ inches; 44 illustrations; indexed. Price, $2.

INDUSTRIAL PLANTS. By Charles Day. The Engineering Magazine, New York. Cloth; 294 pages, 5x7½ inches; 48 illustrations; indexed. Price, $3.

WATER TURBINE PLANT. By Jens Orten-Böving. Raithby, Lawrence & Co., Ltd., London, W. C., England. Cloth; 197 pages, 8½x10¾ inches; 216 illustrations.

MATHEMATICS FOR THE PRACTICAL MAN. By George Howe. D. Van Nostrand Company, New York. Cloth; 143 pages, 4½x7½ inches; 42 illustrations; tables; indexed. Price, $1.25.

ELEMENTS OF GRAPHIC STATICS. By William L. Cathcart and J. Irvin Chaffee. D. Van Nostrand Company, New York. Cloth; 304 pages, 5½x9 inches; 159 illustrations; indexed. Price, $2.

NEW INVENTIONS

Printed copies of patents are furnished by the Patent Office at 5c. each. Address the Commissioner of Patents, Washington, D. C.

PRIME MOVERS

INTERNAL COMBUSTION MOTOR. Karl Fabel, Hamburg, Germany. 985,793.

ROTARY ENGINE. William M. Hoffman, Buffalo, N. Y., assignor to the Hoffman Patents, Ltd., a Corporation of Canada. 985,804.

ELASTIC-FLUID TURBINE. Charles G. Curtis, New York, N. Y., assignor, by mesne assignments, to General Electric Company, a Corporation of New York. 985,885.

ROTARY INTERNAL COMBUSTION ENGINE. Orsemus L. R. Jones, Detroit, Mich. 985,907.

EXPLOSIVE ENGINE. Mathew B. Morgan, Lansing, Mich., assignor of one-half to Oscar M. Springer, Detroit, Mich. 985,920.

ROTARY ENGINE. Hubert I. Call, Spokane, Wash., assignor to the Hercules Rotary Engine Company, Ltd., Wetaskiwin, Canada, a Corporation. 985,974.

ELASTIC-FLUID TURBINE. Charles G. Curtis, New York, N. Y., assignor, by mesne assignments, to General Electric Company, a Corporation of New York. 985,982.

STEAM ENGINE. Christopher F. Laufer, Richmond, Cal. 986,016.

ROTARY ENGINE. Frank Wyle, St. Louis, Mo. 986,116.

TURBINE. Henry F. Schmidt, Pittsburg, Penn., assignor to the Westinghouse Machine Company, a Corporation of Pennsylvania. 986,317.

INTERNAL COMBUSTION ENGINE. Andrew Betts Brown and William Albert Hickman, London, England; said Brown assignor to said Hickman. 986,353.

ELASTIC-FLUID TURBINE. Charles G. Curtis, New York, N. Y., assignor, by mesne assignments, to General Electric Company, a Corporation of New York. 986,368.

ELASTIC-FLUID TURBINE. Charles G. Curtis, New York, N. Y., assignor, by mesne assignments, to General Electric Company, a Corporation of New York. 986,368.

BOILERS, FURNACES AND GAS PRODUCERS

FURNACE. Roy E. Ashley, Muskegon, Mich. 985,878.

OIL BURNER. Adolf Klein, Vienna, Austria-Hungary. 986,067.

WATER-TUBE BOILER. Minott W. Sewall, Roselle, N. J., assignor to the Babcock & Wilcox Company, Bayonne, N. J., a Corporation of New Jersey. 986,089.

STEAM BOILER. Minott W. Sewall, Roselle, N. J., assignor to the Babcock & Wilcox Company, Bayonne, N. J., a Corporation of New Jersey. 986,090.

POWER PLANT AUXILIARIES AND APPLIANCES

FEED-WATER HEATER. Charles Caille, Le Perreux, France. 985,778.

FEED-WATER HEATER FOR PREVENTING PITTING. John C. Parker, Philadelphia, Penn. 985,834.

BALANCED VALVE. Baxter M. Aslakson, Salem, Ohio. 985,879.

GOVERNOR. Ernest L. Nance, St. Louis, Mo. 985,022.

REDUCING VALVE. John Graham and Archibald Graham, Jr., Glasgow, and David Auld Graham, Ruthergien, Scotland. 986,165.

WATER-GLASS GUARD. George Moser, Minneapolis, Minn. 986,199.

ASH DISCHARGER. Frederick P. Palen, Newport News, and William Burlingham, Hampton, Va. 986,208.

ROTARY VALVE. Charles H. Harkins, Derby, Kan. 986,284.

CONDENSER FEED LUBRICATOR. Chas. Cheers Wakefield, London, England. 986,330.

WATER TRAP. Joseph Joy, Donora, Penn. 986,394.

ELECTRICAL INVENTIONS AND APPLICATIONS

ELECTRICAL TERMINAL CONNECTOR. Ray H. Manson, Elyria, Ohio, assignor to the Dean Electric Company, Elyria, Ohio, a Corporation of Ohio. 985,821.

INDUCTION COIL. Richard Varley, Englewood, N. J., assignor to the Autocoil Company, a Corporation of New Jersey. 986,033.

ELECTRIC BATTERY. Carl Jaeger, Seattle, Wash. 986,064.

SYSTEM OF MOTOR CONTROL. William Siebenmorgen and Samuel H. Keefer, Plainfield, N. J., assignors to Niles-Bement-Pond Company, Jersey City, N. J., a Corporation of New Jersey. 986,091.

INSULATING CAP. James C. Phelps, Springfield, Mass. 986,213.

ELECTROPLATING MACHINE. Constantine G. Miller, Chicago, Ill., assignor to the Meaker Company, a Corporation of Illinois. 986,303.

THERMAL CIRCUIT CLOSER. Fredrick C. Guptill, Elgin, Ill., assignor of one-half to William F. Lynch, Elgin, Ill. 986,382.

POWER PLANT TOOLS

CHAIN PIPE WRENCH. George Amborn, New York, N. Y., assignor to J. H. Williams & Co., Brooklyn, N. Y., a Corporation of New York. 985,766.

WIRE-TIGHTENING DEVICE. Henry F. Heitmeyer, Friendship, Ind. 986,058.

WRENCH. John C. McLean, Cleveland, Ohio. 986,192.

ENGINEERING SOCIETIES

AMERICAN SOCIETY OF MECHANICAL ENGINEERS

Pres., Col. E. D. Meier; sec., Calvin W. Rice, Engineering Societies building, 29 West 39th St., New York. Monthly meetings in New York City. Spring meeting in Pittsburg, May 30 to June 2.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

Pres., Dugald C. Jackson; sec., Ralph W. Pope, 33 W. Thirty-ninth St., New York. Meetings monthly.

NATIONAL ELECTRIC LIGHT ASSOCIATION

Pres., Frank W. Frueauff; sec., T. C. Martin, 31 West Thirty-ninth St., New York. Next meeting in New York City, May 29 to June 2.

AMERICAN SOCIETY OF NAVAL ENGINEERS

Pres., Engineer-in-Chief Hutch I. Cone, U. S. N.; sec. and treas., Lieutenant Commander U. T. Holmes, U. S. N., Bureau of Steam Engineering, Navy Department, Washington, D. C.

AMERICAN BOILER MANUFACTURERS' ASSOCIATION

Pres., E. D. Meier, 11 Broadway, New York; sec., J. D. Farasey, cor. 37th St. and Erie Railroad, Cleveland, O. Next meeting to be held September, 1911, in Boston, Mass.

WESTERN SOCIETY OF ENGINEERS

Pres., O. P. Chamberlain; sec., J. H. Warder, 1735 Monadnock Block, Chicago, Ill. Meeting first Wednesday of each month.

ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA

Pres., Walter Riddle; sec., E. K. Hiles, Oliver building, Pittsburg, Penn. Meetings 1st and 3d Tuesdays.

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS

Pres., R. P. Bolton; sec., W. W. Macon, 29 West Thirty-ninth street, New York City.

NATIONAL ASSOCIATION OF STATIONARY ENGINEERS

Pres., Carl S. Pearse, Denver, Colo.; sec., F. W. Raven, 325 Dearborn street, Chicago, Ill. Next convention, Cincinnati, Ohio, September 12-15, 1911.

AMERICAN ORDER OF STEAM ENGINEERS

Supr. Chief Engr., Frederick Markoe, Philadelphia, Pa.; Supr. Cor. Engr., William S. Wetzler, 753 N. Forty-fourth St., Philadelphia, Pa. Next meeting at Philadelphia, June 5-10, 1911.

NATIONAL MARINE ENGINEERS BENEFICIAL ASSOCIATIONS

Pres., William F. Yates, New York, N. Y.; sec., George A. Grubb, 1040 Dakin street, Chicago, Ill. Next meeting at Detroit, Mich., January 15-19, 1912.

INTERNAL COMBUSTION ENGINEERS' ASSOCIATION.

Pres., Arthur J. Frith; sec., Charles Kratsch, 416 W. Indiana St., Chicago. Meetings the second Friday in each month at Fraternity Halls, Chicago.

UNIVERSAL CRAFTSMEN COUNCIL OF ENGINEERS

Grand Worthy Chief, John Cope; sec., J. U. Bunce, Hotel Statler, Buffalo, N. Y. Next annual meeting in Philadelphia, Penn., week commencing Monday, August 7, 1911.

OHIO SOCIETY OF MECHANICAL ELECTRICAL AND STEAM ENGINEERS

Pres., O. F. Rabbe; acting sec., Charles P. Crowe, Ohio State University, Columbus, Ohio. Next meeting, Youngstown, Ohio, May 18 and 19, 1911.

INTERNATIONAL MASTER BOILER MAKERS' ASSOCIATION

Pres., A. N. Lucas; sec., Harry D. Vaught, 95 Liberty street, New York. Next meeting at Omaha, Neb., May 23-26, 1911.

INTERNATIONAL UNION OF STEAM ENGINEERS

Pres., Matt. Comerford; sec., J. G. Hannahan, Chicago, Ill. Next meeting at St. Paul, Minn., September, 1911.

NATIONAL DISTRICT HEATING ASSOCIATION

Pres., G. W. Wright, Baltimore, Md.; sec. and treas., D. L. Gaskill, Greenville, O.

Moments with the Ad. Editor

A department for subscribers edited by the advertising service department of Power

It is interesting to note that interest-in-advertising grows with improvement-in-advertising.

When advertising consisted merely of an effort to see who could shout loudest and longest, interest-in-advertising was at a low ebb.

But with the advertiser's realization that shouting wasn't advertising and that "the truth, the whole truth and nothing but the truth" was wanted, interest-in-advertising was roused out of its sleepy condition, until now it is wide awake.

So wide awake, in fact, that errors in advertising, which would have passed the reader unnoticed a few years ago, are now being called to the attention of the paper in which the advertising appears.

Proof positive that not only the end of advertising improvement has not yet been reached, but also that advertisers today must do more than "just tell the truth."

They must tell things in such a way that no possible chance for misunderstanding can occur; there must be nothing left to the imagination. Misleading statements of all kinds should be avoided. Else not only loss of business will result but a false impression of the advertised goods left in the minds of the readers.

To illustrate, from Spain we receive the following from a subscriber:

"As a general rule the illustrations in the advertisement columns of POWER are of a high order. There are a few which, although they attract the attention of the reader, they offend the critical eye of the engineer and do not make him desirous of opening up business relations with the advertiser.

I call to mind one advertisement which gave a view of a boiler room in which there was an utterly impossible boiler, and with an absurd arrangement of steam pipes which were leaking clouds of dollars at every joint.

The fireman, in the act of throwing a shovel of coal on to the fire, has paused to look at the engineer, who, stripped to the waist, has arrived with a roll of sheet packing to repair what appear to be ordinary screwed joints.

Engineers are trained to study mechanical drawings with their wealth of detail, and photographs of machinery of all classes.

When, therefore, he examines an illustration, he generally does so in order to learn something about the goods advertised, and he is not at all favorably impressed with such impressionist pictures as the one mentioned.

If the advertiser won't present him with a drawing which illustrates a given state of affairs with some degree of truth, he is not at all likely to bestow more than a passing glance at such an advertisement, thinking, naturally, that if the goods equal the quality of the illustration, then he is better off dealing elsewhere.

There is another fault to find with some of the advertisements, namely, the too free use of slang.

In a journal such as POWER, which is by no means limited to one country in its circulation, this is a mistake on the part of the advertiser.

Slang, which may be perfectly intelligible in one country, may spoil an advertisement in the estimation of an engineer of another country, who has not the advantage of an intimate knowledge of the slang prevalent in the country of the advertiser.

I saw one advertisement which stated—"We are putting out the goods that stick." When I looked to see the sticking goods this firm were supplying I saw excellent illustrations of a steam trap and a reducing valve.

As an engineer I certainly do not wish to advise my employers to purchase sticking steam traps or reducing valves.

I don't suppose that the advertiser wishes me to think they do stick, but to me the slang used would convey that impression.

The engineer is a critical person, and this is generally acknowledged by the advertisers who give illustrations of their appliances. These are works of art in the eye of the man trained to straight lines and definite curves.

You do not find idiotic-looking engineers and firemen in these illustrations any more than you do in the engine room or boiler house.

Engineers are generally striving to better their status and you don't usually find these men stripped to the waist, making a joint, or standing at a bar with a pipe in one hand and the schooner of beer in the other, discussing the merit of so and so's no-such square-round-diagonal rod packing.

We are mostly a cut above this, and those advertisers who can't appeal to our liking for exactness and truth are not likely to benefit much by their advertisements."

When prospective customer shows the manufacturer how to aim his advertising to accomplish best results.

Advertising certainly has reached a high point when prospective customer shows the manufacturer how to aim his advertising if he wants to secure best possible results.

And the wise advertiser will heed the warning.

This letter shows conclusively that when advertising is done properly, both advertiser and reader-of-advertising will benefit.

Verily, advertising cannot be done too well.

BUSINESS ITEMS

Phineas G. Staunton, formerly connected with the Peerless Rubber Manufacturing Company, has been appointed New York representative of the Thermoid Rubber Company, of Trenton, N. J. Mr. Staunton's offices are located at 250 West Fifty-fourth street, New York City.

The New York office of the Richard D. Kimball Company, engineers, has been moved from 437 Fifth avenue to 15-17 West Thirty-eighth street. It makes a specialty of the design of both steam and electric power plants, as well as the inspecting and the supervision of existing installations with a view to securing greater economy in operation.

The Westinghouse Electric and Manufacturing Company has just received an order for one 200-k.v.a. rotary converter, two 125-k.v.a. O. I. S. C. transformers and one three-panel switchboard, for shipment to the Nikkon Gas and Electric Company, Nikkon, Japan. The rotary will be used on street-railway service. It is designed for operation at 365 volts, two-phase, 60 cycles alternating current, and 550 volts direct current.

The Cia Beneficiandora de Pachuca de Mexico has recently bought one 915 kva. O.I.S.C. auto-transformer from the Westinghouse Electric and Manufacturing Company, Pittsburg. The 3-phase, 10,000-volt high-tension, 6600-volt low-tension transformer is designed to operate on either 50 or 60 cycles and will connect together two systems, one of 10,000 volts and the other of 6600 volts in case of failure of either system. The transformer will be able to switch the 1000-horsepower load of a compressor motor from one circuit to the other in case of failure of the circuit that is operating.

The Sterling Lubricator Company, of Rochester, N. Y., announces the removal of its factory to Norwich, Conn., where its shops will be combined with those of the Uncas Specialty Company, the new combination to be known as the Sterling Machine Company. The increased shop capacity and generally improved manufacturing facilities will allow room for expansion, furnish better service for the trade and it is further hinted that some new Yankee ideas are at work on new things of interest. On and after March 15 all communications should be directed to the Sterling Machine Company, Norwich, Conn.

Sterling H. Bunnell, M. E., works manager of the Griscom-Spencer Company, has resigned to open an office at 90 West street, New York, as a specialist in factory system and consulting engineer. Mr. Bunnell is the author of "Cost Accounting for Manufacturing Plants," now in press by D. Appleton & Co., as one of their business series. Mr. Bunnell is a member of the American Society of Mechanical Engineers and of the American Gas Institute and has represented the Griscom-Spencer Company in the National Board of Metal Trades. He graduated from the Sheffield Scientific School of Yale University in 1891. Mr. Bunnell has been retained by Clinton H. Scovell & Co., certified public accountants of Boston and Chicago, to take charge of the cost-keeping and factory-efficiency branches of their work, and will also represent them in New York.

The American Ship Windlass Company, of Providence, R. I., reports the following recent orders for Taylor gravity underfeed stokers: Sixteen 7-retort stokers from Stone & Webster for the new Boston Elevated Railway plant at South Boston. Fifty-six 7-retort stokers for New York Edison Company's two Waterside stations. Three 4-retort stokers for the Detroit Public Lighting plant, Detroit, Mich. (repeat order). One 6-retort stoker for the Pfister & Vogel Leather Company, Milwaukee, Wis. The selection of Taylor stokers for the New York Edison Company's plants is of particular interest because of the fact that this company has conducted extensive experiments on various types of stokers since the completion of Waterside station No. 2. The fifty-six stokers ordered will be installed under fifty-six 650-horsepower Babcock & Wilcox boilers, which have heretofore been hand-fired.

NEW EQUIPMENT

Salem, Ore., will install a new lighting system.

M. M. Klein, Roundup, Mont., will erect a brewery.

Madras, Ore., is planning to install a new water system.

Middleboro, Mass., contemplates erecting a municipal gas plant.

Phœnix, Ore., is planning to install a municipal water system.

D. J. Barke, Rockland, Mass., will install a boiler and engine.

Fire destroyed the pump house of Otto Arens, Plainfield, N. J.

The Creamery Company, Belmond, Iowa, will erect a new creamery.

Jaffrey, N. H., will erect a municipal electric-light and power plant.

H. P. Hood & Sons, Boston, Mass., will install a boiler and engine.

The Cobalt (Ont.) Power Company will make extensions to its plant.

Luray, Kan., is considering the establishment of a waterworks system.

W. H. Slaughter, Glendale, Ariz., will establish an ice-making plant.

The Hudson Hat Company, Newark, N. J., will build a new power plant.

Belding Brothers & Co., Belding, Mich., are in the market for three boilers.

The David Tozer Company, Stillwater, Minn., will erect a power house.

The Lillooebt (B. C.) Light and Power Company will erect a new plant.

Dodge City, Kan., has voted $25,000 bonds for electric-light plant and sewers.

Waverly, Va., has voted to issue $7000 bonds for an electric-light plant.

The Union Ice Company, Los Angeles, Cal., will build an addition to its plant.

Portsmouth, Va., has voted to issue $600,000 bonds for establishing waterworks.

Hankinson, N. D., is considering the installation of an electric-light plant.

The John Shepard Company, Providence, R. I., will install a new power plant.

The Seelbach Hotel Company, Louisville, Ky., is to erect a new power building.

The S. A. Woods Machine Company, Boston, Mass., will erect a new power plant.

Riverside, Cal., is contemplating the installation of a municipal water system.

The Home Light Company, Grayson, Ky., will increase the capacity of its plant.

The Peoples Water Company, Oakland, Cal., will build a new pumping plant.

Prince Albert, Sask., will install electrical machinery to develop 10,000 horsepower.

The Imperial Ice Company, Santa Monica, Cal., will build an addition to its plant.

The city of Santa Ana, Cal., will install a municipal water system to cost $20,000.

White Bluffs, Wash., is planning to install an electric system for lighting and power.

The Hunt-Rankin Leather Company, South Peabody, Mass., will purchase a power pump.

The Coal Creek (Tenn.) Electric Light Company will erect an ice plant and laundry.

The Standard Paper Company, South Richmond, Va., is installing a new power plant.

Extensive improvements will be made to the municipal waterworks plant at Coshocton, Ohio.

The Pennsylvania Railway is having plans prepared for a new boiler house at Cleveland, Ohio.

The Tempe (Ariz.) Creamery Company is having plans prepared for a new cold-storage plant.

The Morris Auto Company, South Easton, Mass., will install steam and electric equipment.

The Mission Ice and Fuel Company, San Antonio, Tex., will build a new 25-ton ice plant.

Saskatoon, Sask., will spend $140,000 for machinery for a municipal lighting and power plant.

The Massachusetts Sand Brick Company will install an engine at the West Oxford plant.

Power house of the David Davis Coal Company, Conesville, Ohio, was burned. Loss, $10,000.

The Colonial Ice Company, Cleveland, Ohio, will erect an ice plant of 85 tons capacity per day.

Tappan Brothers, Attleboro, Mass., are figuring on a larger engine to replace the present one.

The McMyler-Interstate Company is erecting a boiler house on the Pennsylvania ore docks, Cleveland, Ohio.

HELP WANTED

Advertisements under this head are inserted for 25 cents per line. About six words make a line.

ENGINEERS WANTED to solicit for the Rolin patent adjustable grate. Apply Standard Grate Co., Heed Bldg., Philadelphia.

WANTED—Thoroughly competent steam specialty salesman; one that can sell high-grade goods. Address "M. M. Co.," POWER.

AN ENGINEER in each town to sell the best rocking grate for steam boilers. Write Martin Grate Co., 281 Dearborn Street, Chicago.

AGENTS WANTED for first-class steam specialty in use throughout United States. Address C. S. Wood, 410 S. 15th St., Philadelphia, Penn.

SALES AGENTS to sell steam turbine blowers, feed water regulators, ventilating fans, pumps, etc.; guaranteed territory; commission. Wing, 90 West St., New York City.

WANTED—An engineer in each city as agent for a high class water-back Scotch boiler, the most economical steam generator known to the trade. Kingsford Foundry & Machine Works, Oswego, N. Y.

ENGINEERING SALESMAN wanted to take charge of New York office for sale of centrifugal pumps and blowers; should be a graduate engineer; write, giving age, experience, references and salary wanted. Address Box 403, POWER.

REFRIGERATOR AND ELECTRICAL engineer wanted at once in a rapidly developing section of the southwest to take charge of forty ton ice plant with electric lighting and power equipment; write fully, stating experience, salary expected, etc. Box 400, POWER.

WANTED—A competent man to do general inspection work for a liability insurance company; must be qualified to assist and instruct other inspectors; expert knowledge of elevators required. Address, stating experience, education, age and whether married or single, Box 399, POWER.

WANTED—Engineer to take charge of 50 kilowatt producer gas plant for electric lighting; applicant must be familiar with Westinghouse gas engines and producers; state age, experience and salary desired; climate very good; living expenses about six dollars a week. Address Arsuaga & Co., Ltd., Box 41, Manati, Porto Rico.

SITUATIONS WANTED

Advertisements under this head are inserted for 25 cents per line. About six words make a line.

WANTED—Permanent position as chief or operating engineer in alternating current and direct current central stations; experienced in steam, boilers, engines, pumps and dynamos; mechanic; technical training; five years' experience up-keep; references. Address Box 402, POWER.

WANTED—Position, manager or superintendent of light and power plant, erection, maintenance and operation, either of steam or gas driven plants; is thoroughly familiar technically and practically, with line work, inside wiring, operation of motors; best of references furnished; now open. Box 397, POWER.

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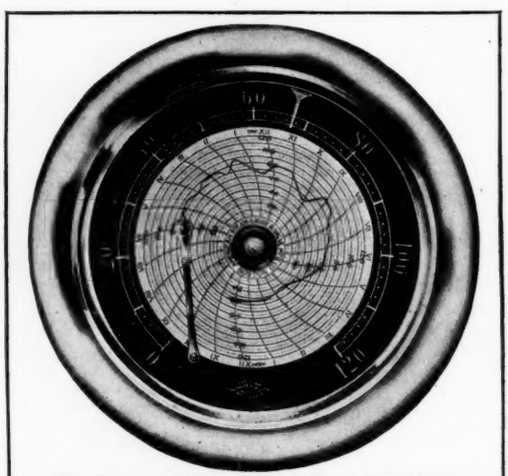

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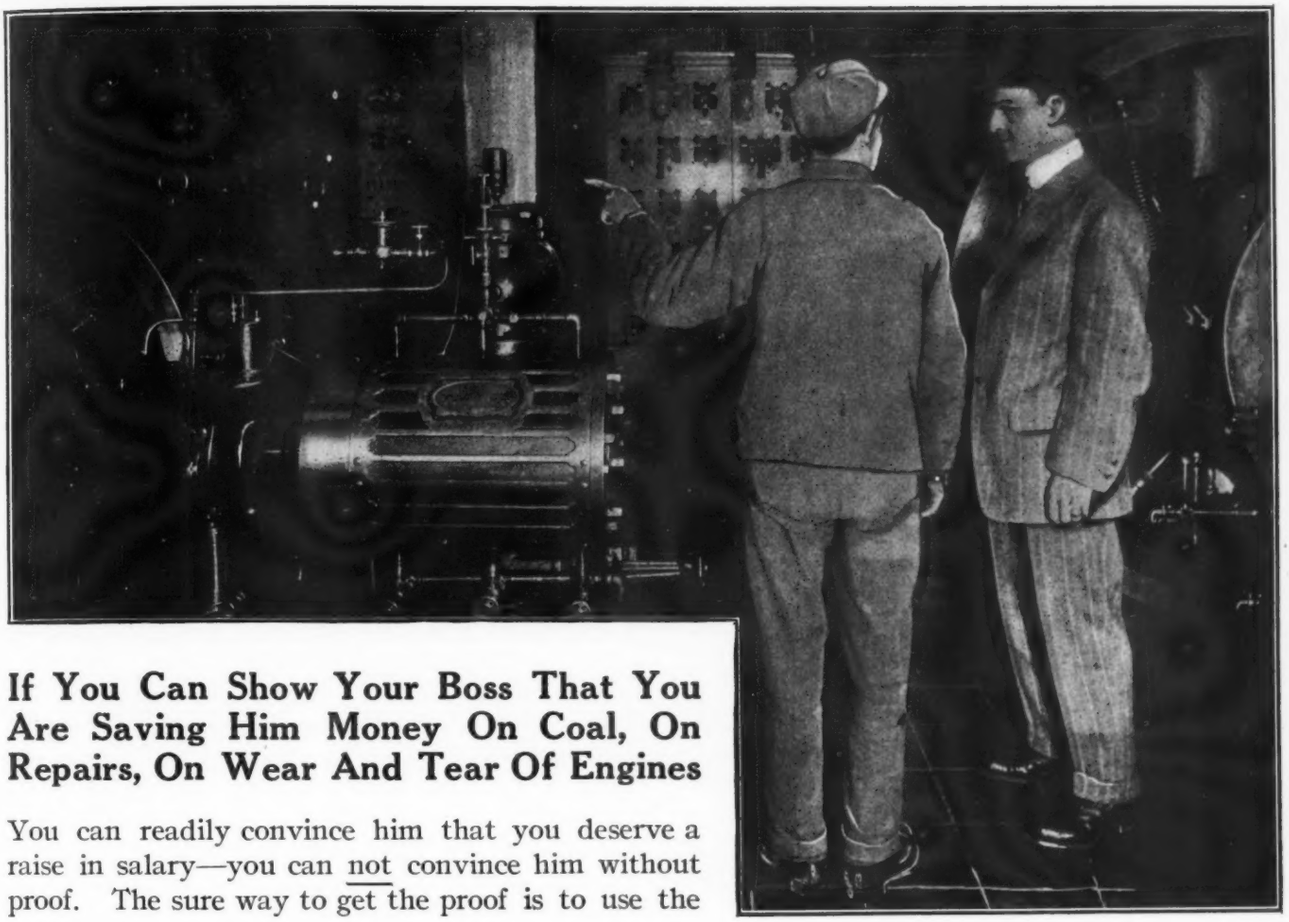

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COCHRANE HEATER

"How hot?" is the principal question that the steam engineer has to answer.

How hot is the water entering the boiler? It should never be much below 210° F., nor need it be if it is heated in a COCHRANE OPEN FEED WATER HEATER receiving the exhaust of auxiliaries, as pumps, fan and stoker engines, etc. If the water has been heated to 210° F. by spraying through the steam-bath of the Cochrane Heater, all air and gases, which are essential to corrosion, will have been driven off, and the driving off of carbon dioxide gas will have resulted in the breaking up of bi-carbonates into the insoluble mono-carbonates, which rapidly settle out of the water, thus keeping that much scale out of the boiler. While the water is hot, it can be easily and conveniently treated with soda ash or other reagent to correct permanent hardness, as in the SORGE-COCHRANE HOT PROCESS WATER SOFTENING SYSTEM.

How hot is the exhaust steam passing to the condenser? This is a better gauge of the vacuum than most vacuum gauges, provided the thermometer be inserted at the steam inlet.

How hot is the tail-water or hot-well water from the condenser? If it is a modern condenser this should not be more than 10 or 15° below the temperature corresponding to the vacuum. Any greater difference indicates imperfect action of the condenser.

By determining **how hot the steam is after it has been wire-drawn through a throttled opening,** the amount of moisture is readily determined, that is, you can make your own calorimeter and appreciate the need of a COCHRANE STEAM SEPARATOR to keep the moisture in the steam out of the engine or turbine.

How hot is the lubricating oil in the bearings? This is an important thing to know.

How hot are the armature and fields of the generator, the switches on the switchboard, and a thousand other things about a power plant?

"How hot" can be answered if you have one of these first-class improved Cochrane thermometers. This thermometer is fitted with a nickel-plated, metal carrying case, with a chain and safety-pin, and has been especially designed for the use of the stationary engineer. **For a limited time it will be sent, together with a copy of our treatise on the**

"Profitable Utilization of Exhaust Steam"

for ONE DOLLAR ($1.00). You could not buy one in the open market at anything like this price. **This offer is open to only one operating engineer in each plant and the name of the plant and the kind of feed heater now in use must be stated.** The book is thrown in so that you may be able to make profitable use of the information about temperatures that you may obtain with the thermometer.

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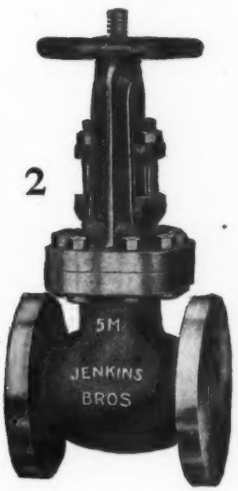

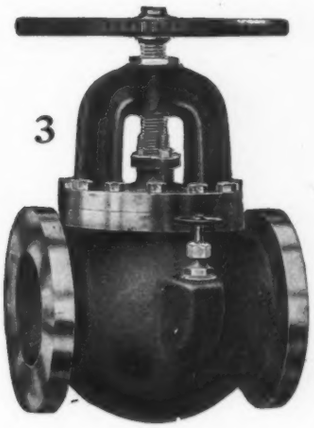

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Every detail of construction is carefully watched and every valve leaving our shops absolutely guaranteed.

The material is carefully selected, the workmanship is of the highest order, and the services thoroughly in keeping with modern power plant needs.

These valves demand little tribute in the shape of attention or repairs.

They are economical valves to use, strong, well built, doing their work day after day as it should be done.

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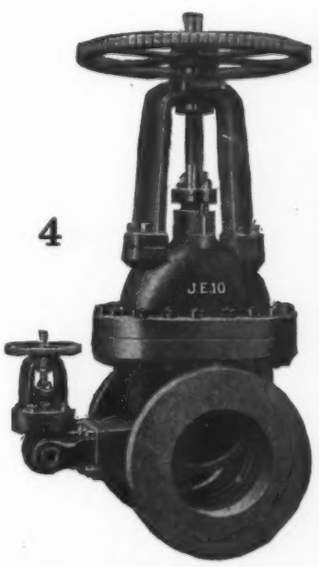

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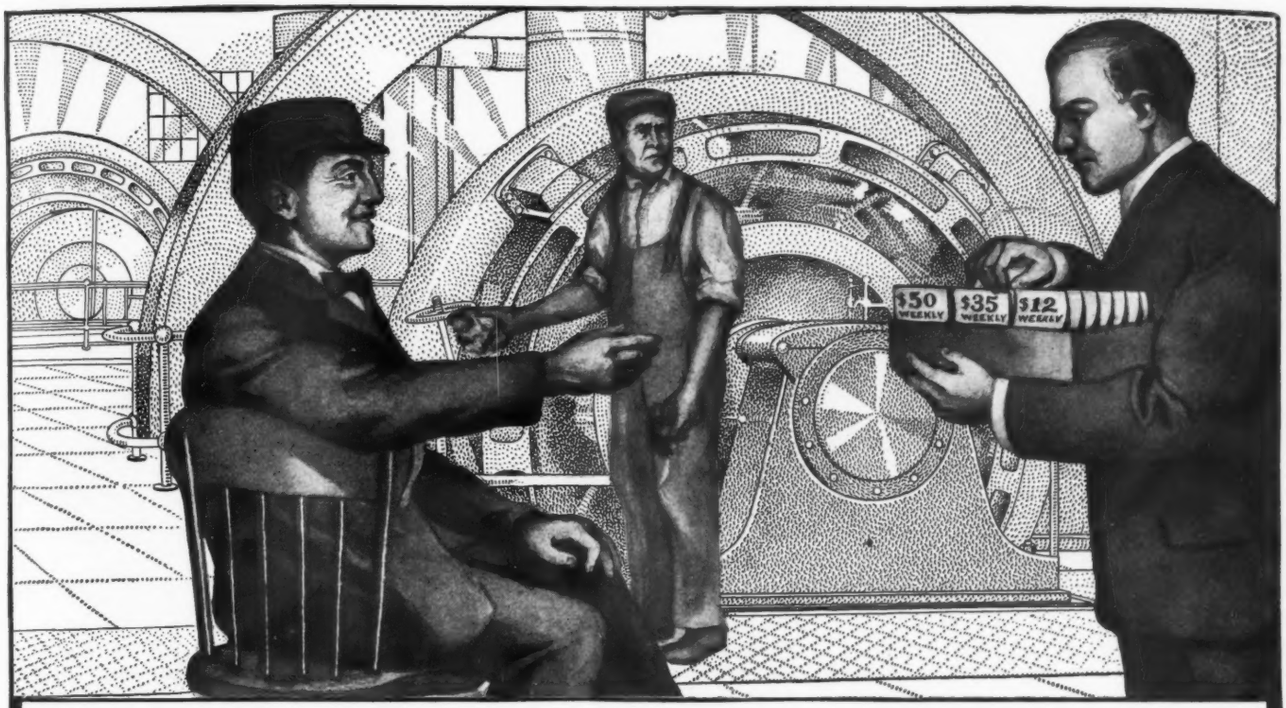

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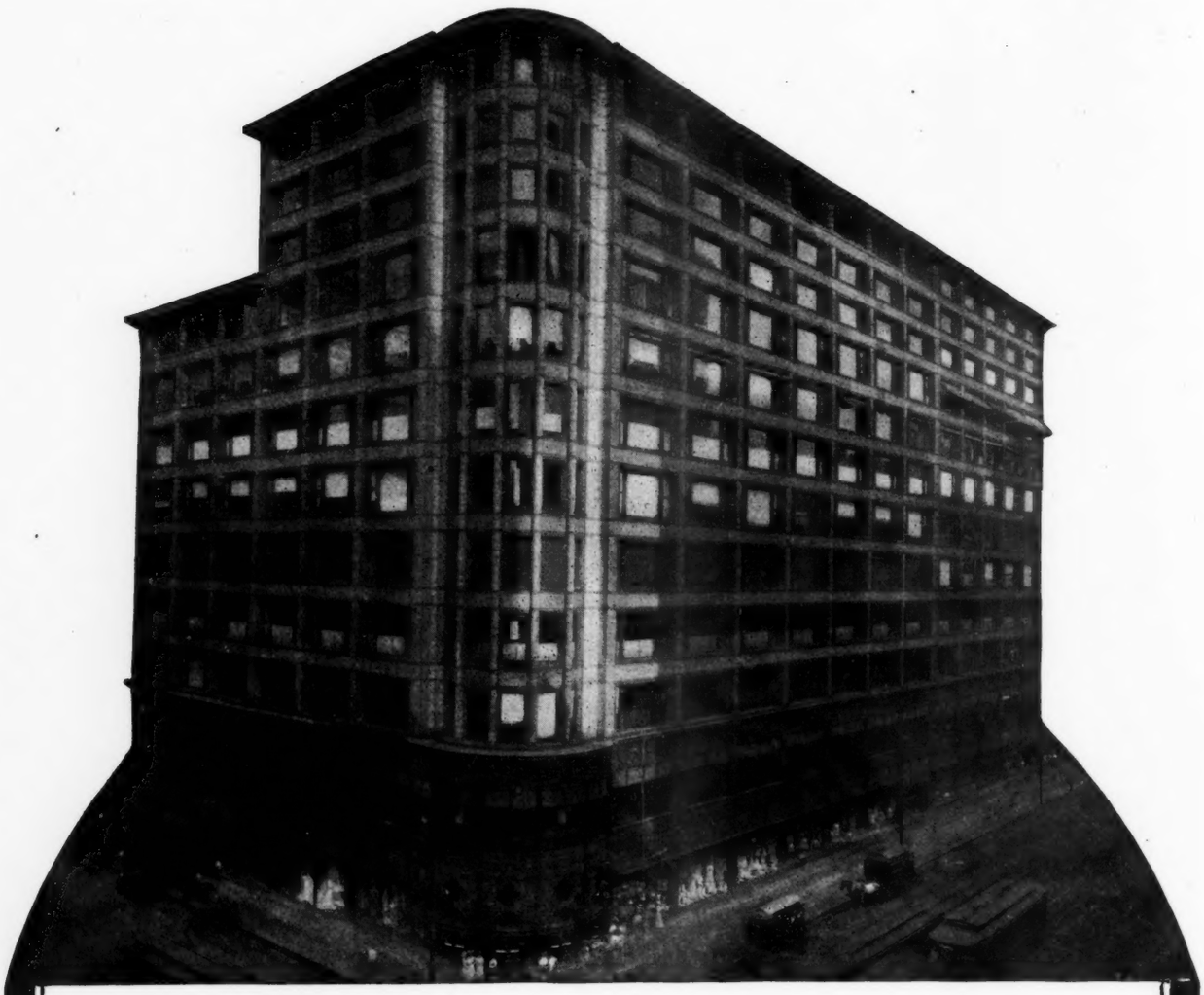

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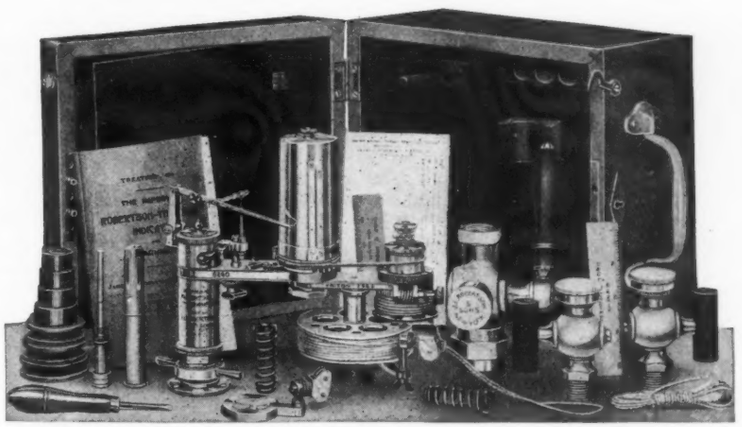

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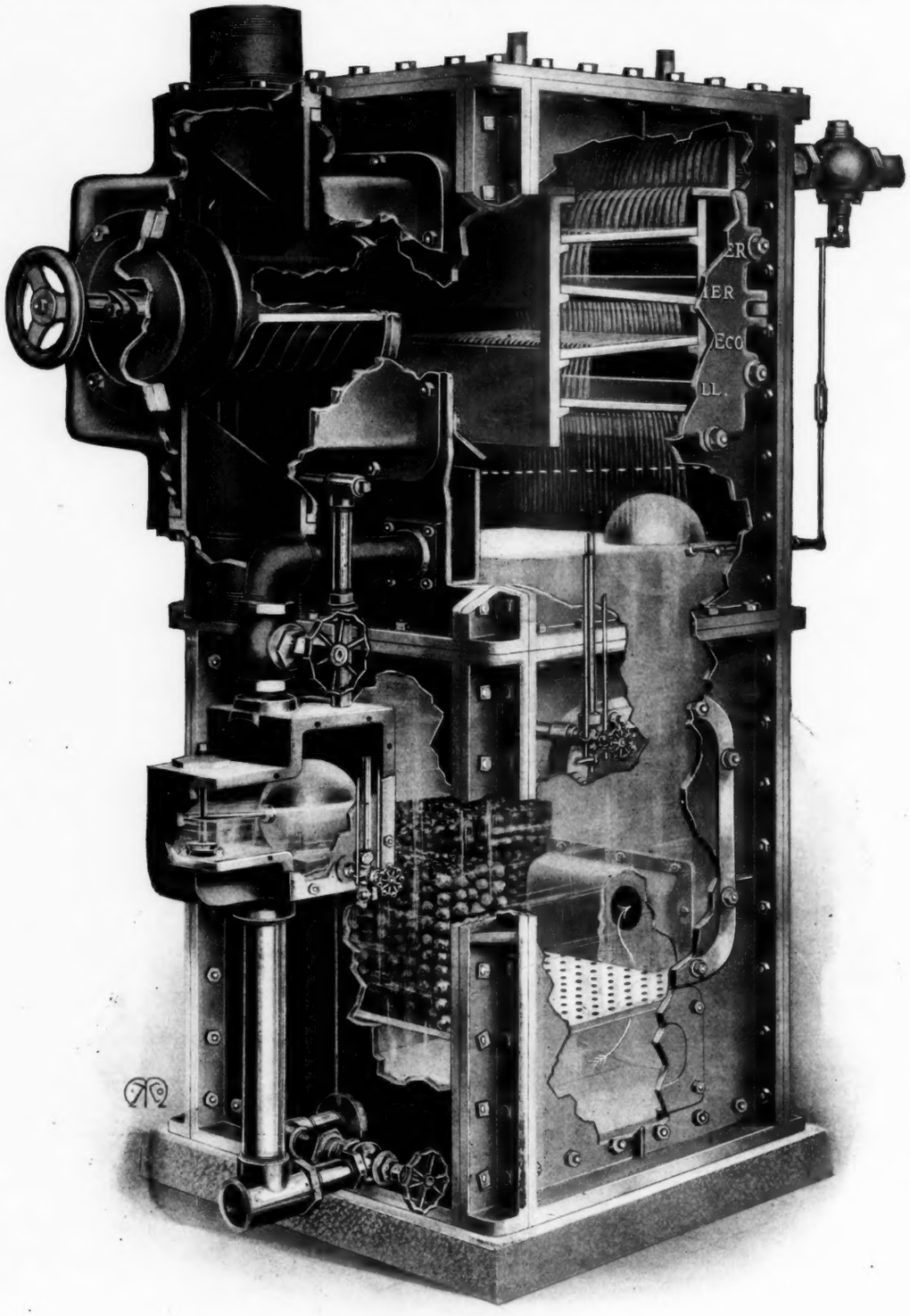
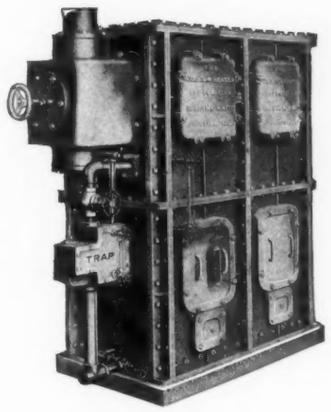


The New Cookson Heater and Receiver with Cut Out Valves and Extra Large Oil Separator

Announcement To Power Users



A NEW type of Cookson Heater as shown on the opposite page has been added to our line and is recommended in preference to all other types for plants where the surplus exhaust steam is utilized in heating, drying or processing systems.

The features of this new heater not found in the ordinary open heater and which make it undoubtedly the best ever offered for its purpose are as follows:

First: An oil separator large enough to purify the entire exhaust from all engines and auxiliaries.

Second: A self-contained by-pass or cut-out within the separator that permits the heater to be cut out for cleaning without interfering with the functions of the oil separator.

Third: Exhaust inlet and outlet connections in a straight line that permit the heater to be cut into a vertical exhaust pipe at least expense for fittings and labor and to take up minimum space.

Ordinarily the oil separator of an open heater is designed to purify only that small part of the exhaust consumed in heating the feed water, while if it is desired to prevent the interior of heating systems from fouling or to re-use the condensation from a hot well or receiver, an additional separator must be installed in the line. The separator of this heater thoroughly purifies an amount of exhaust steam equivalent to the combined condensation and raw water pumped from the heater. In other words, the h. p. rating of the heater separator is equal to that of the boilers or engines which the heater serves.

The self-contained by-pass saves immensely in piping, valves, fittings and in the labor of installing, and the exhaust inlet and outlet being in line and bringing the exhaust pipe snug up against the heater body, affords a further saving in pipe fittings and admits of the neatest piping layout imaginable.

Aside from our usual careful design and construction we desire to call particular attention to the cut-out valve arrangement which is very simple, very effective, more practical, and easier and less expensive to keep in order than any other mechanism for the purpose.

The overflow cut-out is merely a standard globe valve, while the separator cut-out is as simple and works the same way. Both are absolutely positive and close *tight*. There can be no steam leakage as with spring seats when the heater is cut out—a decidedly important feature to the man who must get inside in cleaning. It stands to reason that our simple valves, having no clap-trap parts, and having flat seats with discs held in place both by positive parts and by the pressure of exhaust steam are not so likely to leak as where the valves operate by sliding contact on cylindrical seats and depend merely upon exhaust steam pressure and springs to hold them in place.

If the separator valve of a Cookson Heater should leak, the flat seat can easily be reground, as it can be removed through the flanged opening without taking the separator apart or disconnecting any piping.

We have now tested, proved, retested, improved and installed so many of these heaters under difficult conditions that we know the heating efficiency, the oil separation and the filtration are right. We are therefore ready to demonstrate the conservativeness of our every claim by referring prospective customers to installations where the heater can be seen in service.

Under proper conditions this type of Cookson Heater is bound to effect an ultimate economy that can be pretty closely estimated in advance. Our engineers will advise without charge on this point. We have patterns for all practical sizes and carry in stock those most in demand, hence we can make prompt deliveries. Write for our new catalog.

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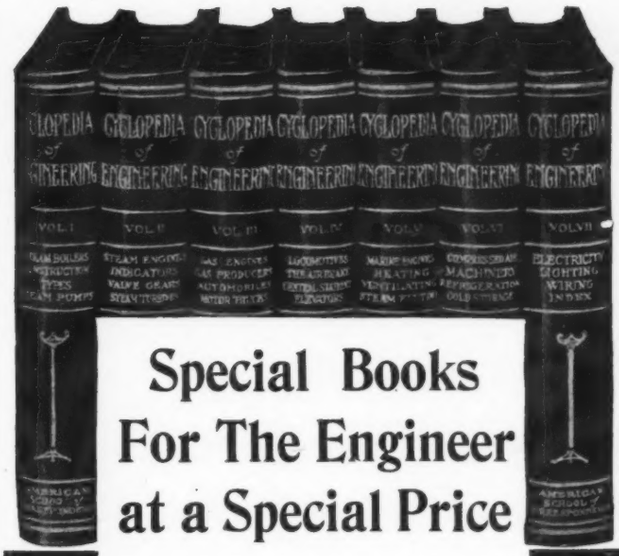

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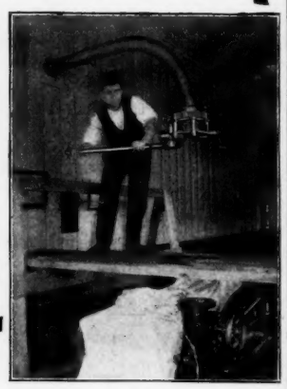

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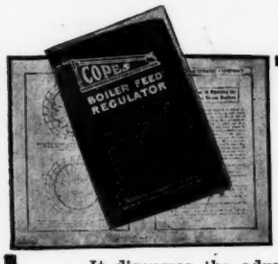

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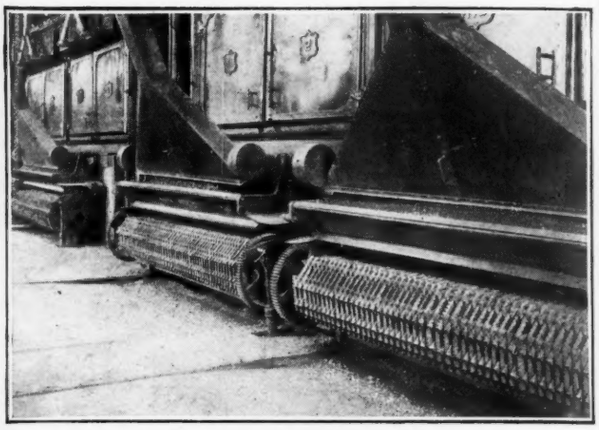

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